Gas Journal

INSTITUTION NUMBER

VOL. 294. 110th YEAR. LONDON, MAY 21, 1958. Nº 4949. PRICE 2/6

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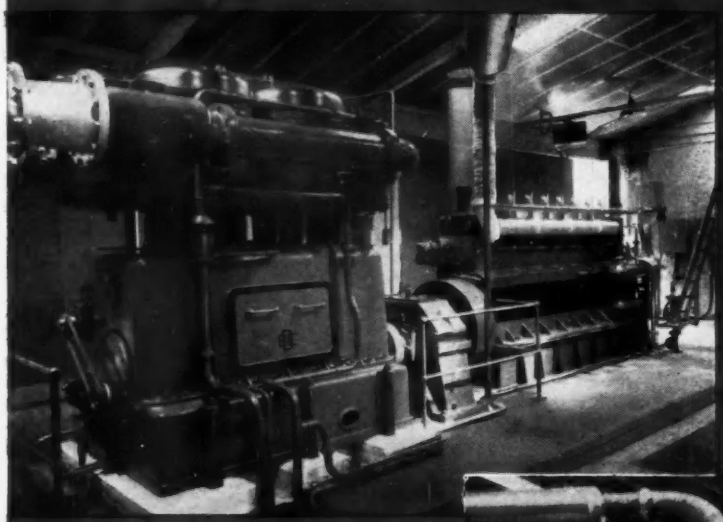

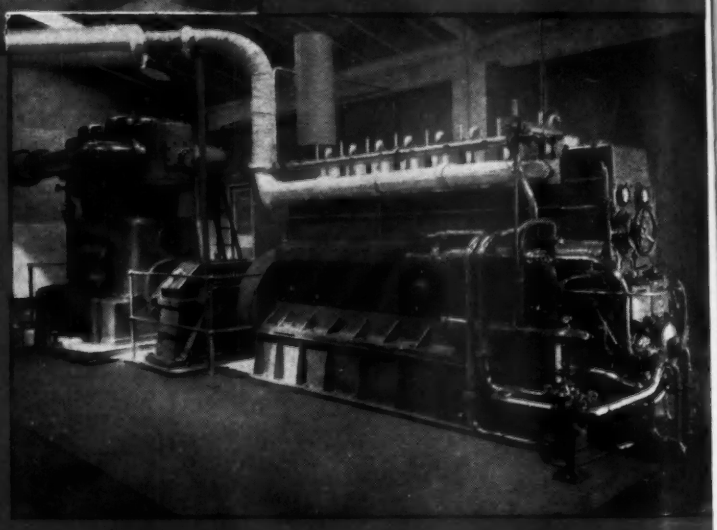

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Gas Journal

VOL. 294 NO. 4949 21 May, 1958

110TH YEAR

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Published by Walter King Limited,
11, Bolt Court, Fleet St., London, E.C.4

Telephone: FLEet Street 2236-7 Telegrams: Gasking, Fleet.

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PUBLISHERS' NOTICE, See Page 327, May 14, 1958

illustration by courtesy of H. E. Wingfield & C...

something in common

They remind one of different worlds, the 1d. black postage stamp of 1840, and the modern T.G. meter. Yet, they *have* something in common—both are the products of true craftsmanship. First issued on 6th May, 1840, the 1d. black was printed by Perkins, Bacon & Co. from an engraving by Frederick Heath. The design was based on a watercolour by Henry Corbould from the City Medal engraved by William Wyon, and is presented as a fine example of the engraver's art. The T.G. meter epitomizes craftsmanship and the T.G. 'G' prepayment mechanism is accepted as the most modern precision movement on the market.

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DR. JAMES BURNS, G.M.

President of the Institution of Gas Engineers, 1957-58

Gas Journal INSTITUTION NUMBER

Vol. 294. No. 4949. May 21, 1958

The frontispiece and all photographs of the meeting published in this issue were taken by Stephen Tennant, A.R.P.S., 'Gas Journal' Staff Photographer.

Review

of the Meeting

THREE things endear the Festival Hall to us as a venue for the annual general meeting of the Institution of Gas Engineers : The fact that you can hear what the speakers are saying; the spaciousness, which permits one to circulate among one's friends in comfort and even achieve comparative solitude if in the mood for quiet reflection; and the warmth of the furnishings which impart to the eminent gentlemen on the platform an added distinction and a certain mellowness. (All the same, those gentlemen seem to be a long way away!) In addition there is that indefinable something which gives to the South Bank an atmosphere (albeit less exciting than that of the Left Bank) which has in its rather nautical quality an undeniable attraction.
All these things contributed to our enjoyment of the 95th A.G.M., but they were dwarfed by the factor which, surely all must agree, made this an outstanding meeting. We refer, of course, to the personality, punch, precision and pre-eminence of this year's President, Dr. James Burns, G.M. Here is a man whose suitability for this honour, firmly based on his high technical standing in the industry, is enhanced by personal qualities which are, to say the least, enviable. It was his crisp chairmanship and easily recognised warmth of manner which helped to lift this meeting out of the ordinary.

The papers too were well up to standard, although we cannot help wondering whether the practice of allowing the president's board to have the lion's share of the programme can be carried too far. Six of the eight papers presented stemmed from the North Thames Board, either direct or under the guise of Watson House. (How much longer, we wonder, must there be this ridiculous situation in which Watson House serves two masters when it should serve only one—the Gas Council?) Even having regard to the unquestionable wealth of material, animate and

inanimate, to be found in this area, taking a slice which represents three-quarters of the programme might fairly be described as hogging it!

In listing the 'credits' it would be unfair not to comment on the excellence of the organisation. The fact that the Secretary, Dr. W. T. K. Braunholtz, and his staff achieve this triumph year after year tends to make one take everything for granted. Perhaps the most complimentary way of putting it is to say that the machinery works so smoothly that one is not conscious of the wheels going round.

Overseas Visitors

Early in the meeting the President extended the traditional welcome to visitors from overseas. And what a list it was! There were from Australia Messrs. A. Hume Reid (Woodall-Duckham (Australasia) Pty. Ltd., Melbourne), E. B. Wight (Norman J. Hurll & Co. (Victoria) Pty. Ltd., Melbourne), Max Watt (Gas and Fuel Corporation of Victoria, Melbourne), and P. G. Ryan (Parnall (Australia) Pty. Ltd., North Sydney, N.S.W.); from Austria, Dr. J. Seitlinger (Gas Works, Linz); from Belgium, G. Devos (Cokeries du Brabant, Vilvorde); from Denmark, R. Jakobsen (President, Danish Gas Association); from France, A. Bolzinger (President, French Gas Association); from Germany, Dr.-Ing. E. A. Schaack (Cologne); from Italy, Dr.-Ing. V. de Biasi (President, Italian Gas Association); from Japan, Kunio Banno (Toho Gas Company, Ltd., Nagoya); the Netherlands, J. H. Steinkamp (Secretary, Netherlands Gas Association); from South Africa, D. E. Terrace (Cape Town and District Gas Light and Coke Co., Ltd.); and from Switzerland, Mr. Jordi (Member of Council, Swiss Gas Association); and H. L. D. Raeber (Secretary, Swiss Gas Association).

After the Secretary had read a telegram of greeting from Dr. Mario Boselli, President of the International Gas Union, we came to the results of the ballot for the election of Officers, Auditors and Ordinary Members of Council for 1958-59. They were as follows: President, Mr. E. M. Edwards; Vice-President, Mr. H. S. Cheetham; Hon. Secretary, Mr. G. E. Currier, O.B.E.; Auditors, Sir Harold Smith, K.B.E., D.L., and Mr. Peter D. Davey, F.C.A.; Ordinary Members of Council, Mr. L. W. Andrew, Mr. F. L. Atkin, Mr. W. Hodkinson, O.B.E., Mr. L. J. L. Walker.

It was reported that Dr. R. Lessing, President of the Clean Air Society, and Mr. R. H. Touwaide, General Secretary, International Gas Union, had been duly elected as Honorary Members.

The names of the District Members of Council nominated by the District Sections of the Institution and affiliated District Gas Associations, were as follows: Mr. A. L. Allen (Dublin), Irish; Mr. S. E. Balsom (Letchworth), Eastern; Mr. F. H. Bate (Dudley), Midland; Mr. J. C. Hogg (Bournemouth), London and Southern; Mr. A. McFadyen (Glasgow), Scottish; Mr. T. L. Tallentire (Cheltenham), South Western; Mr. I. W. Thomas (Aberystwyth), Wales and Monmouthshire; Mr. J. G. Tilley (Huddersfield), Manchester and District; Mr. J. A. Tomes (Stourbridge), British Junior Gas Associations' Joint Council; Mr. F. J. Webster (Stockton-on-Tees), North of England.

Scrutineers of ballot selected for the ensuing year were Messrs. L. W. Andrew, F. L. Atkin, S. E. Balsom, and J. C. Hogg.

Presidential Address

And so to the Presidential Address about which we had our say last week. Suffice it to add that we can remember few such addresses that produced as much favourable comment from members after the meeting. More formal but no less sincere were the compliments paid Dr. Burns by Mr. T. C. Finlayson, who moved the vote of thanks and Mr. R. S. Johnson, who was the seconder.

Mr. Finlayson gave his remarks an unusual twist: 'For reasons which are quite irrelevant,' he said, '18 months ago I happened to be almost the first person to encircle the running track at the Olympic Stadium at Melbourne. I then saw the bowl from which the Olympic gas flame was to ascend in a few days. As I read our President's Address I was reminded of that incident. During the past year or two, a new flame has, most appropriately, been lit at Murdoch House to guide the gas industry forward into a new era of opportunity. In his Presidential Address, and indeed throughout his year of office, Dr. Burns has acted as a most effective torch bearer, carrying this new flame forward. In fact, for many years, through the ever-changing technical phases of the gas industry, our President has always been a torch bearer in the forefront of new ideas and new developments.'

'A Lost Opportunity'

And of the fact that by custom the Presidential Address is not the subject of discussion, Mr. Finlayson lamented 'What a lost opportunity this time, if I may say so!' He summed up the address neatly by calling it 'the paper pattern for our New Look.'

Mr. R. S. Johnson referred to the President's comment that 'the gas engineer today is confronted with an almost bewildering array of techniques'—a statement which, he said, could not fail to evoke general assent, and to give rise in the minds of the audience to sensations in which either caution or courage would predominate according to temperament. 'The days have gone by when the gas industry could rely exclusively on the carbonisation of traditional gas-making coals for meeting its base load, and on the

Les girls!

Typical South Bank scenery. The imposing line of coaches indicates that it is departure time, for I.G.E. members taking part in the organised visits.

well-known carburetted water gas process for meeting the peaks,' said Mr. Johnson. 'In our search for the cheaper therm we are having to devise ways of using a wider range of the basic raw materials. We are becoming familiar with the utilisation and treatment of refinery gases and the catalytic gasification of oil. In addition, as the address so clearly shows, we have to give consideration to the gasification of low-rank coal by various processes; the hydrogenation of oil and later of low-rank coal to produce a gas low in sulphur and carbon monoxide; and also the importation of liquid natural gases. The gas engineer may well feel that his problems today are formidable, but in their solution lies the hope of the future.'

There was something rather special about the presentation of medals and prizes this year in that the Birmingham Medal which, as the President said, 'is not given very lightly and it is not given often,' went to 'a very great friend of the gas industry,' Sir Harold Hartley. In expressing his appreciation Sir Harold referred to 'that dynamic personality, David Milne Watson, to whom I owe a great debt of gratitude for bringing me into the gas industry where I spent nearly 25 very happy years.' And of the President, he said: 'I remember when you joined the great Company for which we both worked and how we quickly realised that you were going to play a great part in the gas industry in the future.'

Medals and Prizes

The President then presented the following medals and prizes:

Institution Gold Medal, 1957, to E. R. Ward, M.INST.GAS E., for his Paper on 'The Use of Light Petroleum Distillate for Gas Making,' read at the 23rd Autumn Research Meeting of the I.G.E. on November 20, 1957.

H. E. Jones London Medal, 1957, to R. S. Andrews, C.M.G., D.SC., M.I.CHEM.E., F.R.A.C.I., M.INST.F., for his Paper on 'Pressure Gasification of Brown Coal at Morwell, Australia, read at the 94th annual general meeting of the I.G.E., on May 14, 1957. Dr. Andrews was not present and the Medal was received on his behalf by his colleague, Mr. Wight.

Institution Silver Medal, 1957, to E. Spivey, PH.D., B.SC., M.INST.GAS E., and C. H. Williamson, ASSOC.M.INST. GAS E., for their Paper on 'The Production of Water Gas at Beckton,' read at a meeting of the London and Southern Section of the I.G.E. on January 5, 1957.

Institution Bronze Medal, 1957, to J. R. Kilvert, ASSOC.FUEL(SHEFF.), M.INST.GAS E., for his Paper on 'Operating Results at the New Swan Village Gas Works,' read at a meeting of the Midland Junior Gas Association, on December 17, 1957.

William Dieterichs Memorial Prizes, 1957. Duplicate awards to (*a*) A. H. Bird, M.B.E., ASSOC.M.INST.GAS E., for his Paper on 'The Effects of Variations in the Combustion Characteristics of Town Gas on Certain Industrial Processes,' read at a meeting of the Eastern Section of I.G.E., December 4, 1957. (*b*) H. R. Cooke, M.INST.GAS E., M.INST.F., A.M.S.E., for his Paper on 'Industrial Application of Air Heated

Mr. E. B. Wight, who received the H. E. Jones London Medal on behalf of Dr. R. S. Andrews.

★

Sir Harold Hartley, President of the Society of Instrument Technology, admires the Birmingham Medal which he has just received from the President.

★

Mr. J. R. Kilvert, winner of the Institution Bronze Medal.

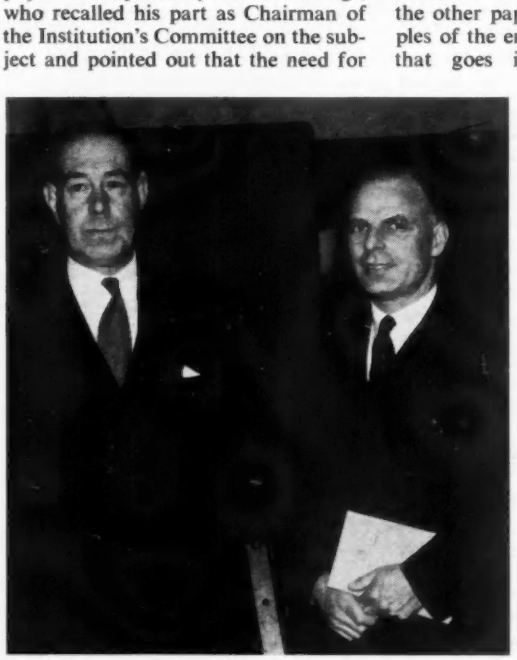
by Gas,' read at a meeting of the London and Southern Junior Gas Association on April 5, 1957.

At the conclusion of the prize giving we came to the first paper of the day. In this, 'Materials and Structures,' S. V. Gardner, Engineer Designer, N.T.G.B., showed how important good design is in reducing the maintenance costs of plant and structures. He pointed out that the extra cost involved in the original construction should always be set off against this subsequent saving. The industry should always be ready to use the most modern materials available to withstand the corrosive atmosphere of the gasworks. Such a combination would enable the industry to build plant at the most reasonable cost together with functional advantages and good environment so that it might become more competitive.

The discussion was unaccountably short but at least this had the virtue of ensuring that the President's Luncheon (reported elsewhere in this issue) kept to schedule.

When we reassembled it was to hear a trilogy of papers all dealing with aspects of the faithful old battle cry 'Sulphur Must Go'—except that for the first time we heard the cry from one author that 'Sulphur Has Gone.' These three papers on the complete removal of sulphur from town gas, by L. J. Clark and E. Spivey, C. H. Purkis (all of the N.T.G.B.), and W. Wedgwood, of the Jersey Gaslight Co., Ltd., were taken together by the President to show the problems to be faced in its removal, the effect of residual sulphur on appliances and its effective removal to 5 gr./100 cu.ft. in a catalytic plant regularly supplying a 'district.' The discussion on these papers was opened by Dr. H. Hollings, who recalled his part as Chairman of the Institution's Committee on the subject and pointed out that the need for sulphur-free gas was becoming so pressing that should it be disregarded any longer, the main gas load might conceivably go the way of the lighting load.

The courage and enterprise of a comparatively small undertaking like the Jersey Company in installing a catalytic sulphur removal plant did not go unnoticed, but when competition among free enterprise fuel industries becomes fierce, as might easily happen in Jersey, the need to improve the weapons of the gas salesman becomes imperative. This and the success of the Company's policy in increasing gas sales and decreasing appliance maintenance on the district was clearly shown in Mr. Wedgwood's paper. Both the other papers were excellent examples of the enormous amount of work that goes into collecting accurate



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Mr. H. R. Cooke and Mr. A. H. Bird, who were jointly awarded the William Dieterichs Memorial Prizes.

★

information and, in Mr. Purkis' paper in particular, how much experimental work is needed to prove a case beyond doubt, which might seem almost obvious to a consumer of 'ordinary' town gas.

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Reception and Dance

Their sulphurous deliberations over, members retired in good order to prepare for the night's junketing. The reception and dance, held in the Great Room at Grosvenor House, was enjoyed by all. How strange it always is to note the fleetness of foot displayed by gas engineers, in such marked contrast to the measured tread with which they patrol their works or pace their office floor. Aided by the smooth rhythm of Sidney Lipton's aggregation, revelry continued until the small hours, and it was a tribute to the author of the first paper the following morning that so many members had taken up action stations at the Festival Hall to hear him.

The author in question was J. A. Buckley, of the Eastern Division, N.T.G.B., who described in some detail in his paper 'Domestic Marketing: Comment and Conjecture,' what are the problems facing a gas salesman, and the developments that have taken place to assist him behind the scenes. He was careful to explain that he used the word 'marketing' in preference to 'sales' or 'selling' to cover al the processes involved. The proper organisation of service was a great help to sales, he said, and if the cost of this could be reduced as much as possible by an integrated emergency night service and a means by which the consumer could get in direct touch with the appropriate department without difficulty, the added confidence in the gas industry should prevent the housewife looking elsewhere for her fuel services.

Benevolent Fund

There followed the Annual General Meeting of contributors to the I.G.E. Benevolent Fund, and then we turned our thoughts to industrial gas and in particular to 'Utilisation Efficiency of Gas Appliances,' a paper by E. A. K. Patrick, Officer-in-Charge of the industrial laboratory at Watson House. The author clearly showed the difficulties that may arise from an incomplete understanding of the basis on which such efficiencies are measured. The need to dispel any doubt in a possible buyer's mind as well as in the designer's, when considering the merits of a piece of plant, necessitate the exact definition of the processes involved in different sections of the plant. The modification of the simple thermal efficiency formula as the ratio between the heat transferred to the work and the heat of combustion of fuel used, to the ratio between the heat transferred and the heat available above working temperature seems a fairer way of measuring heating efficiency of a furnace.

Mr. Sam Hall, Sales Director of Thos. Glover & Co., Ltd., with Dr. W. T. K. Braunholtz, Secretary of the Institution.

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The Visits

This seemed to us a useful and necessary piece of work, and the subsequent discussion was a good one. With contented minds, therefore, we turned our thoughts to the afternoon's attractions. There was a choice of five places to visit—Beckton, Romford, B.C.U.R.A, George Kent, Ltd., and Coryton. The last visit proved to be the most eventful, and if those taking part saw less of the refinery than they had hoped, at least they brought back with them the bones of a first-rate after-dinner story.

Very few undertakings work up their own by-products, and today the majority rely on the co-operative tar distillers in different parts of the country. The paper by L. W. Blundell, Controller of by-products, N.T.G.B., on 'By-products in the Economy of Gas Manufacture,' which was the curtain-raiser on Thursday morning, was interesting in its description of the processes employed at the products works at Beckton. At one time tar distillation and the production of coal tar derivatives was considered more an art than a science, but now with the better understanding

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Mr. A. G. Higgins, Assistant Secretary of the Institution, with Mr. L. J. Walker, of R. & J. Dempster, Ltd.

★

of the scientific principles involved, there is no need for all the secrecy which was considered necessary at one time. The use of modern continuous plant demands good transport arrangements for crude from other works of the board.

Work Study

And so to the last paper of the meeting. The application of work study to the gas industry is a comparatively new conception. It has been applied successfully to the chemical industry, and much of the information and methods in use have been derived from this source. The paper by D. Beavis, General Manager of the Edinburgh Division of the Scottish Gas Board, gave an interesting progress report after three years' working. The general theme of the paper's presentation seemed to be that work study enabled management to manage better every bit as much as it enabled the workman, or even the office worker, to carry out his particular job better and more easily.

With Mr. Beavis's paper we reached the end of the 95th A.G.M. save for the 'last rites'—the votes of thanks. The first of these was slipped in by the President (usually on the receiving rather than the proposing end at this stage of proceedings). He thanked the Chairman of the Gas Council, Sir Harold Smith, for supporting the meeting each day and accepting the invitation to sit at the 'top table.' Dr. Burns concluded: 'We thank you, Sir Harold, as Chairman of the Gas Council, as leader of the gas industry, as a very great supporter of the Institution, as a past President of the Institution, and as Sir Harold Smith.'

For a man apparently playing five different rôles Sir Harold Smith was remarkably (and admirably) brief in his response. He referred to the number of younger people growing up in the Institution and taking part in the discussions and commented: 'I think the level of the discussions which have taken place during this meeting has been excellent. It is improving every year, but I thought today particularly the level of the discussion of this last paper reached a very high standard indeed.'

This year the omnibus vote of thanks was entrusted to Mr. F. G. Pyper, Chief Engineer of the East Midlands Board, seconded by Mr. L. J. L. Walker, Managing Director of R. & J. Dempster Ltd. We feel we must quote Mr. Pyper's remark on the organisation of the meeting. 'We have come to expect that these meetings will run with clockwork precision and this has been no exception,' he said. 'I am sure none of us realises the amount of work and anxiety involved in dealing with the general organisation and with the hour to hour problems which must arise. We count ourselves fortunate indeed in our Secretary and his staff.'

Dr. Braunholtz, acknowledging the vote of thanks, exhibited his usual modesty when he said: 'I am quite the wrong person to thank you for your vote of thanks because I myself and our staff are concerned in only the last and a very, minor capacity.' And he went on to claim that the success of the meeting was due to everyone else instead. But, of course, we all knew better than that!

Mr. E. M. Edwards spoke of 'a most memorable Presidential year,' memorable for many reasons: 'The outstanding success of our November Research Meeting; the very great and spectacular success of the meeting which is about to terminate; the vitally important and outstanding Presidential Address that we had the privilege of listening to this week, which shows so clearly the way ahead, the imprint of original thought and the action of a virile and energetic mind running right through it.'

Summing up, Mr. Edwards said: 'We all are the richer and the Institution is the stronger for the forthright, vigorous, yet friendly leadership which you, Mr. President, have shown throughout this year which is about to end.' And he proposed that the best thanks of the Institution be accorded to Dr. Burns for the excellent manner in which he had so well guided all their affairs, for the untiring energy and great ability which he had invariably displayed in connection with the work of the Institution, for the dignity with which he had enhanced their proceedings, and for the friendliness he had shown to them all.

Mr. G. V. C. Davies, Director, Humphreys & Glasgow Ltd., seconded the proposal, and then Mr. Edwards handed Dr. Burns the Presidential certificate.

Memorable

Dr. Burns replied as follows: 'The Presidency of the Institution of Gas Engineers is a very stimulating and enjoyable experience indeed. . . . I think really the success of the Institution depends primarily upon its members. There may be other "frills" attached to it but the success of any professional body or any technical institution is dependent absolutely on how much every individual member is prepared to put into it, and not how much he is prepared to take out of it.'

So ended a meeting as memorable as any we have enjoyed for a long time, one which was of particular importance in that throughout the emphasis was on new markets, new techniques and new horizons. For those who may have been beset by doubts about the future, the whole meeting must have proved a salutary experience.

HIS LAST MEETING

Sgt.-Major J. G. Cutler, who is about to retire after 26 years in the gas industry. The Sgt.-Major, who is usually to be seen guarding the doors of 1, Grosvenor Place, has for many years been a familiar figure at Institution meetings. Before joining the gas industry he served for 25 years in the Royal Navy as Chief Petty Officer.

BENEVOLENT FUND

AT the annual general meeting of the contributors to the Benevolent Fund of the Institution of Gas Engineers, the Chairman, Dr. J. Burns, stated that 55% of the members of the Institution contributed to the Fund. Although this was not bad, he would have been delighted if the remaining 45% had seen fit to contribute.

In no case could the Welfare State help the recipient of money from this fund and in many cases it was the recipient's only income. In other cases the money was used on a wider basis to help the young dependants of some unfortunate person associated with The Institution.

Mr. S. K. Hawthorne and Mr. S. J. Simpson were elected to the Committee of Management for 1958-61.

C.H.PURKIS ESQ.
L.W.BLUNDELL ESQ
W.WEDGWOOD ESQ
S.V.GARDNER ESQ
L.J.CLARK ESQ
DR.J.BURNS
D.BEAVIS ESQ
J.BUCKLEY ESQ
DR.E.SPIVEY
E.A.K.PATRICK ESQ
DRAWN BY SPARK

SULPHUR

Stronger efforts are being made to grapple with this ever-fresh problem, as these three Institution Conference papers which follow testify

1. The Sulphur Impurity in Town Gas

by

L. J. CLARK, *B.E.M., M.Sc.(Eng.), M.I.Mech.E., M.Inst.Gas E., A.M.I.C.E., A.M.I.E.E., A.M.I.Chem.E.,*

DEVELOPMENT ENGINEER,

and

E. SPIVEY,

Ph.D., M.Inst.Gas E., A.M.I.Chem.E.,

SENIOR CHEMICAL ENGINEER
NORTH THAMES GAS BOARD.

THIS paper reviews in the light of present-day circumstances the case for the further removal of the small amount of organic sulphur compounds present in gas either manufactured or purchased by the gas industry for town supply. In the authors' view, the quality of most of the gas supplied by the industry satisfies all but one of the standards required to ensure good consumer service. The exception arises from the presence in purified town gas of small amounts of organic sulphur compounds consisting chiefly of thiophen, carbon disulphide, mercaptans and carbon oxysulphide.

Incidental

Much has been said in the past concerning the desirability of distributing town gas having a reduced and controlled content of sulphur impurity. Some effort has also been applied to the development and proving of processes for the removal of this sulphur impurity either alone by catalytic decomposition or in association with benzole recovery. Mainly because of economic factors, however, the catalytic process is not being used on any appreciable scale, and the only successful large-scale removal of sulphur compounds is at present dependent on and is in the main incidental to the recovery of benzole. It is generally recognised that the domestic market is the mainstay of the industry, and that, of the many uses for gas, those that offer the most promising fields for expansion are for water heating and space heating. In respect of the latter, it cannot be expected that expansion in the use of gas for flueless appliances will increase so long as the sulphur impurity remains at its present general level.

If, by reducing the sulphur impurity in town gas, more could be sold, the economics of gas supply need not be prejudiced; for example, it can be shown that, if the cost of increased sulphur removal at the works imposed an additional cost of 0.5d. per therm on all the gas made, this could be offset in the form of useful therms to the public by increasing the use of gas in flueless appliances by only about 4% of the total sales.

Legislation has barred the presence of hydrogen sulphide in town gas since 1860. It is not generally known, perhaps, that between the years 1860 and 1905 the total sulphur content of the gas distributed in London and many provincial towns was also limited by law. Although the statutory obligations to remove total sulphur were withdrawn in 1905, the necessity for complete removal of hydrogen sulphide still remains. To guard against the risk of being reported and perhaps prosecuted for an offence within the meaning of the Gas Act, 1948, it is general practice to reduce the hydrogen sulphide concentration in town gas near to or below an average concentration of 0.2 p.p.m.

95th A.G.M. — a 'GAS JOURNAL' Abstract

COMM. Mo. 523 AND DISCUSSION

It is recognised that hydrogen sulphide is a corrosive gas and that there must be a limit on the quantity permitted in town gas. The standard of hydrogen sulphide removal that the present official test compels the industry to maintain is, however, unnecessarily high.

The 1941 Committee of Enquiry appointed by the Council of the Institution of Gas Engineers to consider the question of the removal of sulphur from town gas recommended an immediate reduction to below 10 grains per 100 cu.ft. by applying processes that had then proved practicable, and called attention to the further advantages which would accrue by still further reducing the concentration to below 3 grains per 100 cu.ft. This latter recommendation was particularly applicable to flueless space heating appliances where conditions of combustion, room space and air-change might not be altogether satisfactory, and annoyance might be caused by smell from products.

In regard to the corrosion of appliances caused by the products of combustion of town gas, the Committee referred to the investigations carried out by the Joint Research Committee at the University of Leeds between 1933 and 1937, which showed that, under condensing conditions, the rate of corrosion of all metals, with the exception of lead, decreased considerably when the sulphur content was reduced below 8 grains per 100 cu.ft., which decrease continued steadily as the sulphur content was reduced further. With lead and its alloys, on the other hand, no corrosion was found when the sulphur content of gas was above 4 grains per 100 cu.ft., but some became evident when the sulphur was reduced below that level.

In order to facilitate comparison of the sulphur impurity content of town gas with that of other competitive fuels, Table 1 shows sulphur contents expressed as grains per therm of net potential heat content. In the case of town gas, the first value represents the sulphur equivalent of the normal trace of hydrogen sulphide present in gas purified so as to satisfy the official test with a good factor of safety.

TABLE 1.—*Sulphur Content of Fuels.*

Fuel	Sulphur Content	
	Usual Basis of Expression	Grams per therm of Net Potential Heat
1	2	3
Town Gas	0·2 p.p.m.H_2S.	0·03
	3 grains per 100 cu. ft.	6·7
	10 grains per 100 cu. ft.	22
	30 grains per 100 cu. ft.	67
Refinery gas (to N.T.G.B.)	3 grains per 100 cu. ft.	2·5
Refinery gas after Reforming	0·5 grains per 100 cu. ft.	1·0
Commercial propane and butane	0·02% by weight	7·5
Paraffin	0·05% by weight	18·5
Light distillate (P. F.D.)	0·05% by weight	19·0
Gas oil	0·9% by weight	325
Fuel oil	3·5% by weight	1,400

This comparison shows quite clearly that, if town gas is to compete in overall performance with paraffin, its sulphur content must not be greater than about 8 grains per 100 cu.ft. A still lower level of near to 3 grains per 100 cu.ft. must be attained if town gas is to retain existing and gain new industrial loads (against the competition of liquid propane or butane fuels), where low sulphur content is important.

At present, the average sulphur content of town gas is believed to be between 20 and 25 grains per 100 cu.ft., if one excepts gases made from low-sulphur coals.

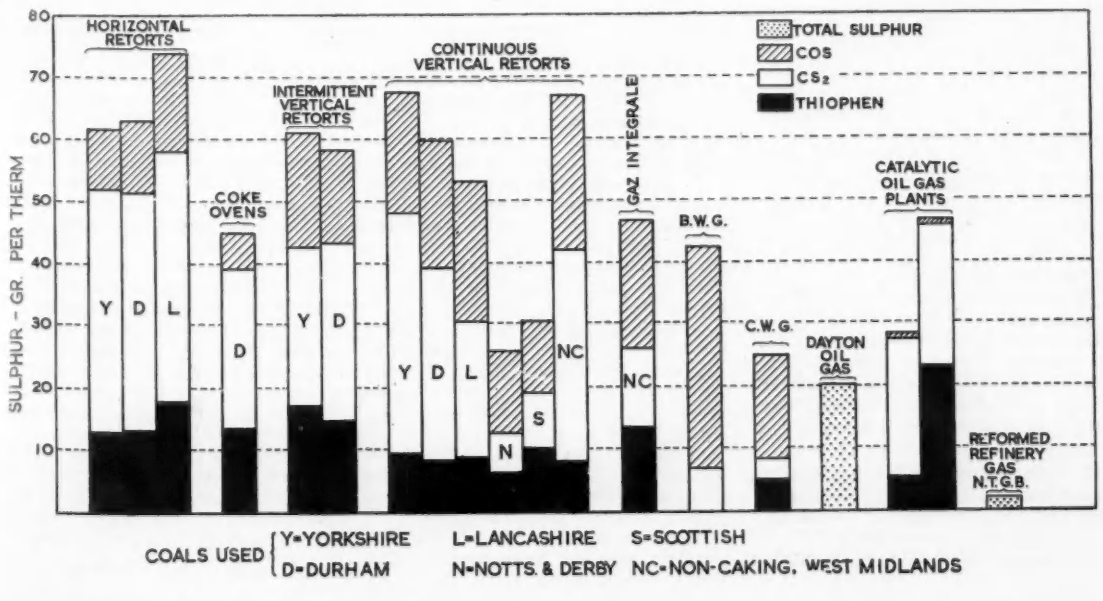
The purified brands of paraffin, now largely used in flueless appliances are becoming a serious rival to town gas on account of their very low sulphur content and high heating value. Selling at about 24d. per gal., paraffin yields, when burnt in a flueless appliance, one therm of useful heat for 16d. Town gas, which contains appreciably more than 10 grains of sulphur per 100 cu.ft., and which, therefore, cannot be burnt satisfactorily in flueless appliances, will yield up to 0.65 therm of useful heat for each therm of gas when supplied to the best type of convector fire. If the price of gas is 22d. per therm, the cost of the useful heat therm to the consumer is 34d.

The sulphur compounds present in town gas after removal of H_2S consists mainly of thiophen, carbon disulphide, carbon oxysulphide and traces of mercaptans.

The quantities of these compounds present in different types of manufactured gas after purification from hydrogen sulphide, and before any treatment for removal of benzole and organic sulphur, are shown in the accompanying figure at foot of page.

Downward Trend

As regards sulphur removal from gas carried out in conjunction with benzole recovery, a considerable number of plants for the extraction of benzole were installed between the years 1937 and 1942 when conditions were such as to make benzole recovery profitable, but few new plants have been commissioned since that time on account of the downward trend of benzole recovery profits. Benzole recovery in itself often shows a loss, but its reinstatement in modified form designed primarily as a means of removing sulphur might well be a sound



investment. This applies to both the oil washing and the active carbon processes.

A method by which some degree of sulphur removal can be maintained through active carbon or oil-washing plants when calorific value limitations exist involves returning a large proportion of the benzole to the gas after fractional distillation to remove the bulk of the carbon disulphide. Because, however, the thiophen cannot be completely separated from the benzole returned to the gas, the overall reduction of sulphur achieved is not likely to exceed about 50%. A more attractive method to restore, or even to increase further, the calorific value of the stripped gas is to replace the benzole by butane/propane or by another rich gas produced from a low-sulphur-content oil. By this method, the sulphur content of the stripped gas, assessed in terms of its heat content, may be further reduced.

By operating the carbon adsorption process in a special manner, it is possible to reduce the sulphur content of normal town gas to about 20% of its original amount. This can be achieved by shortening the adsorption cycle time so that gas does not continue to flow through the carbon after the beginning of the sulphur break point when the concentration of sulphur in the gas passing over the carbon becomes greatly increased by the release of sulphur compounds, once adsorbed, but then being displaced by benzole. The practicability of producing low-sulphur-content gas by the use of the carbon process operated with a shortened adsorption cycle was proved over a period of six months of continuous working on the large plant at Beckton, when the sulphur content of the gas was 30.5 grains at the inlet and 6.1 grains per 100 cu.ft. at the outlet, giving an extraction efficiency of 80%.

Carpenter-Evans

There are three catalytic processes for the removal of sulphur from town gas which have been proved practicable on the commercial scale. The first was the Carpenter-Evans process invented about 45 years ago, which employed a nickel-subsulphide catalyst. The sulphur compounds were hydrogenated to form hydrogen sulphide at temperatures ranging from 420°-440°C. The H_2S was then removed by iron oxide. Owing to formation of carbon on the catalyst, it was necessary to regenerate the latter after every 30-35 days' working. About 70% of the carbon disulphide and lighter sulphur compounds were so decomposed. Experiences with this process showed that certain modifications were desirable; for example, deposition upon the catalyst of carbon from the gas could be greatly reduced by operating at a lower reaction temperature with a catalyst of increased activity.

The next process to be tried was the Gas Light and Coke Company's, which also used nickel subsulphide and operated at temperatures between 230° and 360°C. The method of heating the catalyst differed from that of the Carpenter-Evans process (which employed external heating by producer gas) in that the heat was produced by the combustion of hydrogen and oxygen from the gas on the catalyst. This resulted in the formation of oxides of sulphur together with small quantities of H_2S. After-purification involved washing with alkaline solution followed by iron-oxide removal of hydrogen sulphide.

The third catalytic process, which is operated at the present time at a few works, is the Holmes-Maxted method which uses a metallic thiomolybdate catalyst, the sulphur compounds being hydrogenated to H_2S which is afterwards removed in oxide boxes. The temperature of the reaction is 330°-380°C. and heating is carried out partly by external gas firing and partly by the combustion of hydrogen and oxygen in the gas.

The tables following, give results of 'efficiency,' as they affect the different sulphur compounds left in gas after normal purification, points to one way, by combining proved processes, of achieving the lower level of sulphur impurity of about 3 grains per 100 cu.ft. which, sooner or later, the industry will have to accept as an essential quality requirement for town gas.

Series Operation

The oil washing and active carbon benzole-recovery processes and the catalytic processes can all remove carbon disulphide from gas, but the oil-washing process alone can be designed, with some saving in capital and process costs, selectively to remove thiophen from the gas. It appears correct, therefore, to consider series operation of the limited oil-washing process for removal of benzole and thiophen followed by catalytic treatment for removal of carbon disulphide and oxysulphide. By so combining the two processes, it would generally be possible to reduce the sulphur content of normally contaminated mixed gases to below 5 grains and possibly to below 3 grains per 100 cu.ft.

The active carbon recovery process operated in series with a catalytic process plant would give equal or even better results because the overall slip of carbon disulphide would be less. The combined operating costs would be greater than for the oil-washing and catalytic process combination though the overall difference might only be small due to the better quality of benzole yielded by the carbon process. It is known that carbon replacement costs are reduced when a catalytic process plant operates before a carbon plant, because the catalytic process removes essentially all the gum-forming nitric oxide from the gas.

TABLE 2.—*Removal of Individual Sulphur Compounds, by G.L.C.C. Catalytic Process.*

Impurity	Inlet (grains per 100 cu. ft.)	Outlet (grains per 100 cu. ft.)	Removal (per cent)
1	2	3	4
Thiophen	10·2	10·2	0
Carbon disulphide	16·3	0·9	95
Carbon oxysulphide	7·2	2·5	65
	33·7	13·6	60

TABLE 3.—*Removal of Individual Sulphur Compounds by Holmes-Maxted Catalytic Process.*

Impurity	Inlet (grains per 100 cu. ft.)	Outlet (grains per 100 cu. ft.)	Removal (per cent)
1	2	3	4
Thiophen	4·5	3·6	20
Carbon disulphide	14·5	1·3	91
Carbon oxysulphide	4·1	1·8	56
	23·1	6·7	71

obtained with the G.L.C.C. and the Holmes-Maxted processes:

The practicability and economics of these processes depend in part on the methods adopted to remove these decomposition products from the gas.

It has been suggested that catalysts might be prepared which would be capable of both decomposing the sulphur compounds and of absorbing the products of decomposition in one stage. A zinc-oxide catalyst is mentioned in this connection.

A disadvantage of the use of these catalytic processes is the comparatively low thiophen removal efficiency. It is improbable therefore that any of them, unless improved in efficiency would reduce the organic sulphur content of coal gas containing about 30 grains per 100 cu.ft. of total sulphur, including more than 7 grains of thiophen, to a level consistently below 10 grains.

The fact that benzole-recovery and catalytic processes have reverse orders

While, by the coupling up of approved unit processes, as described above, the sulphur impurity in town gas of the average quality being produced at the present time can be reduced to a satisfactory level, there is clearly an urgent need for a single process to perform the same duty without, at the same time, removing any other constituents from the gas. The possibility of finding better catalysts or of improving the performance of those already used for removal of sulphur have not yet been fully exhausted, and it is suggested that the industry might find this to be a rewarding line of research.

Depends on Cost

Whether or not the gas industry decides to tackle more energetically and comprehensively the problem of reducing the sulphur content of the gas it distributes will depend in the end on the cost of that operation. On the one hand, the cost might force up the price of gas sufficiently to produce a drop in the level of total sales, even though the possibility of selling more gas for space heating by flueless appliances would be improved. On the other hand, the cost of removing sulphur might be low enough to be absorbed within the existing price structure due to the increased sale of gas used for space heating.

Tables are given showing the costs of sulphur removal by the active carbon and the oil-washing processes of benzole recovery, and also of removing sulphur by the G.L.C.C. and the Holmes-Maxted catalytic processes.

TABLE 4.—*Benzole Recovery Process.*

Operating Costs	Active Carbon Recovering 2·5 gal. per ton (pence per therm) of gas treated)	Intensive Oil Washing Recovering 3·2 gal. per ton (pence per therm) of gas treated)
1	2	3
Attendance and supervision	0·030	0·027
Make up carbon or oil	0·037	0·015
Steam, electrivity, water	0·154	0·220
Gas booster attendance and other charges	0·041	—
Loading crude benzole and transport to refinery	0·013	0·016
Maintenance of plant (equalised)	0·032	0·023
	0·307	0·301
Charge for gas lost at 13d. per therm	0·753	0·903
Total cost of recovery (no capital charges)	1·060	1·204
Value of product	0·898	1·039
Less	0·162	0·165
Charge for capital (replacement value)	0·126	0·139
Less	0·288	0·304
Sulphur removal	60 to 70%	60 to 70%

TABLE 5.—*Operating Costs for G.L.C.C. Catalytic Process.*

	Pence per Therm
1	2
Power requirements for gas, air and liquor pumping	0·027
Fuel cost of hydrogen burned, charged at 13d. per therm	0·131
Supervision and labour	0·026
Cost of catalyst regeneration and replacement	0·072
Soda ash for removal of sulphur dioxide	0·026
Oxide purifier operation	0·015
Maintenance and repair	0·083
Total operating costs	0·380
Capital charges	0·220
Total cost	0·600

TABLE 6.—*Operating Costs for Holmes-Maxted Catalytic Process.*

	Pence per Therm
1	2
Power requirements	0·008
Fuel cost for gas burnt externally and hydrogen burnt internally at 11d. per therm	0·183
Labour	0·039
Cost of catalyst regeneration and replacement	0·010
Total operating cost (excluding removal of hydrogen sulphide)	0·240
Capital charges	0·128
Total cost (in 1957 and excluding removal of hydrogen sulphide)	0·368
Total cast (present-day)	0·41
Cost of removing hydrogen sulphide (by Manchester process)	0·19
Total Cost	00·6

TABLE 7.—*Total Costs of Removing Sulphur from Gas.*

Scheme	Process	Sulphur Removal (per cent)	Sulphur Slip grains p. 100 cu. ft.)	Total Cost (pence per therm)
1	2	3	4	5
1	Limited oil washing	30	17·5	0·20
2	Intensive oil washing, active carbon	66	8·5	0·30
3	As for Scheme 2, but 50% of benzole product charged full customs duty	66	8·5	0·63
4	Catalytic process as at present proved in performance	66	8·5	0 60
5	Limited oil washing preceded or followed by catalytic process	W80	W5	0 80
6	Active carbon process with shortened adsorption cycle	80	5	0·40
7	Intensive oil washing or active carbon followed by zinc oxide catalyst process	W90	W2·5	0·70
8	Catalytic process of improved efficiency and with reduced heating costs	80	5	0·55

To facilitate comparison of the many process costs for different methods and degrees of sulphur removal, the results are summarised and related to the treatment of a standard gas containing about 25 grains per 100 cu.ft. of total sulphur made up of 5 grains of thiophen, 13 grains of carbon disulphide, and 7 grains of carbon oxysulphide. It is assumed that the gas contains not less than 0.25 gal. of benzole per 1,000 cu.ft.

Less Expensive

Despite the fact that recovery of benzole is not now profitable, removal of sulphur with benzole is still less expensive than removal by a catalytic process. The active carbon process operating with a reduced adsorption period shows the lowest cost, at the present time, for reducing sulphur in gas to the 5 grains per 100 cu.ft. level. The catalytic process, when fully developed, might show costs not significantly higher.

The authors suggest that, notwithstanding the financial implications, the gas industry as a public service has a responsibility to deal with the sulphur problem as expeditiously and effectively as though it were a requirement imposed by legislation.

2. Sulphur and Gas Appliances

by

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SULPHUR affects appliance design in two major ways: First, corrosion-resistant materials or finishes may be required when condensation is liable to occur; secondly, the accumulation of products of corrosion must neither impair the safety of the appliance nor cause annoyance to the user. Installation practice is also affected by imposing unnecessary limitations on the flueless use of gas, since sulphur oxides may give rise to smell, and in conjunction with water vapour may produce acidic condensate. Finally, the presence of sulphur oxides in the products of combustion may be unacceptable for certain industrial processes.

The newer types of domestic and commercial space heating appliances are increasing in importance and the corrosion problem is a growing one so far as space heating is concerned. The steps for combating corrosion in an economically satisfactory manner generally imply regular maintenance, a requirement that has long been accepted as inevitable with instantaneous water heaters, but may be relatively novel with space heaters.

Intermittent

In the flueless heating of churches problems arise if gas is employed without full understanding of what is involved. On account of the highly intermittent character of the demand, flueless heating by gas, particularly with overhead radiant panels, is attractive. The difficulty is that, if a number of such heaters are lit in a cold building of massive construction, and if the standard of ventilation is low, initial condensation is liable to occur. If this is acidic, it can cause damage to the pipes and mechanisms of organs and to brasses and other metal objects in the church. If it is not possible to provide a mixture of flued and flueless heaters, and to ensure the necessary standard of ventilation, it may be that flueless gas heating cannot be considered.

The corrosion problem that inevitably arises if sulphur is present is particularly acute with non-condensing instantaneous gas water heaters, which are made of copper, on account of its good thermal properties and ease of fabrication, and incorporate finned heat exchangers in order to combine high thermal efficiency with a big safety margin on combustion, together with virtual freedom from condensation except at the moment of lighting. Corrosion of these heat exchangers can lead to restriction of air flow, and, ultimately, to incomplete combustion.

A survey of more than 700 non-condensing instantaneous water heaters was recently carried out by four specially selected examiners in the North Thames Gas Board Area. The survey was equally divided between two areas, one receiving gas containing about 25 grains sulphur per 100 cu.ft., while the other received half this amount. The difference in the general condition of the heaters in the two areas was most marked, and was confirmed by interchanging the examiners between the two areas. As a result of this survey, it has been decided to double the time interval betwen routine maintenance visits over a large area served by gas containing less than 15 grains sulphur per 100 cu.ft.—an interesting practical confirmation of the laboratory finding concerning the proportionality between sulphur content and corrosion rate.

For many years, protection of copper against corrosion by sulphur oxides has been afforded by dipping the heater body after fabrication in an alloy usually containing about 80% lead and 20% tin. In view of corrosion problems it is clearly desirable either to find some better method of protecting copper or to use some other material.

In view of the well-known ability of lead to withstand attack by sulphuric acid, it has generally been assumed that the ideal solution would be to coat the body and heat exchanger of a water heater with pure lead. Unfortunately, pure lead will not adhere to copper, but, at the suggestion of the British Non-Ferrous Metals Research Association, heat exchangers have been dipped, some in lead containing about 0.1% of nickel, and some in an alloy of 97.5% of lead, 1% of tin and 1.5% in silver, and these have been compared with the conventional 80:20 lead/tin tip. Indications based on three heat exchangers of each type are that the 'life' is increased by about 25% when new, as compared with the conventional dip. It is doubtful whether the added cost (due to the higher melting-point of the alloy) and greater difficulty of obtaining a uniform coating would be justified by such a modest increase in performance, but investigations are continuing.

It is difficult to fabricate treated sheet, and almost equally difficult to coat sheet, other than by dipping, after it has been fabricated. Experiments have been made with copper heat exchangers sprayed with aluminium from a powder gun, and the process seems worthy of further study. The possibility of introducing chromium by vapour diffusion is also under consideration, though the high temperature required may adversely affect the brazing.

It is well known that a range of gas circulators and storage heaters are available with combustion chambers constructed of corrosion-resistant steel. The merits of this material from the corrosion point of view have been fully established, but there are grave difficulties in applying it to instaneous heaters owing to its much lower thermal conductivity. The consequent higher fin temperature means that considerable heat is stored in the heat exchanger, which could lead to severe after-boiling in an instantaneous heater. A provisional patent has been filed for a design that overcomes this problem, and its commercial practicability is now being explored.

There is no doubt about the superiority of aluminium over copper from the point of view of corrosion by sulphur oxides in the products of combustion of the gas, however, apart from fabrication difficulties, which will certainly be greater than with copper, the problem arises of corrosion of aluminium by water. It is well

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known that hard waters containing a relatively high proportion of dissolved copper produce intense local corrosion of aluminium, leading to pitting and perforation. The trouble is aggravated if the water is stagnant, as it would certainly be for long periods in a heater constructed in this way. Various methods of chemical and mechanical protection, including the use of clad tubing, are now being investigated. A gilled aluminium tube with copper liner appear to offer important advantages, but differential expansion on heating caused premature breakdown of the bond between the metals.

Industrial Gas

In the industrial gas field, the presence of sulphur in town gas can affect either the appliance or the product.

The corrosive effect upon the appliance does not call for special comment, since it is similar in nature to that experienced in other fields of gas utilisation. The only point to be made is that, where industrial appliances are used continuously, the opportunity for condensation to occur is less; by no means all industrial gas equipment, however, is used continuously.

Sulphur, in the concentrations normally encountered in town gas, has negligible effect on a large number of industrial heating processes; indeed, in a number of instances, town gas is preferred to fuel oil as having a considerably lower sulphur content. There are, nevertheless, processes in which sulphur gases can be decidedly deleterious, and these constitute a valuable portion of the industrial load. Three major examples are processes concerned with glass, ceramics, and the heat treatment of non-ferrous metals.

Gas has always been universally used for the flame working of glass, but when glass is heated in the presence of sulphur oxides a 'bloom' is formed on its surface. This 'bloom' can easily be removed by wiping or washing, and its formation toughens the glass; nevertheless, it is very disadvantageous when, for example, it forms on the inside surface of a television tube during the process of welding the face to the body. Another aspect of this same problem is the 'bloom' that forms on vitreous enamel during firing if sulphur is present; this spoils the appearance of the finished product, and for this reason direct gas firing is not employed in vitreous-enamelling furnaces. Another large use for gas in the glass industry is in the annealing of mass-produced glassware, which must remain free from 'bloom.' As a result, such processes must either be indirectly heated, or catalytic sulphur removal be provided locally.

Pottery Kilns

Sulphur oxides affect certain colours and glazes on ceramic bodies, and, in consequence, pottery kilns are commonly indirectly heated. In one instance the availability of gas containing less than 10 grains of sulphur per 100 cu.ft. enabled the installation of a direct-fired kiln fired by town gas and consuming some 120,000 therms per annum. Had the kiln been indirectly heated, the fuel chosen would have been oil.

The clean heat treatment of non-ferrous metals, such as silver, copper, nickel, and their alloys is a very important heating load, and, if acceptable results are to be obtained, sulphur-free atmospheres must be provided. As before, this can be done by the provision of local catalytic plant, but this increases the effective price of the gas.

Perhaps a greater disadvantage of the presence of sulphur in town gas lies in the fact that, once its presence is known, it is in many instances assumed, without evidence, to be deleterious in circumstances where this is not in fact the case. This results in the unnecessary installation of indirectly heated appliances; it is in the ability to be used directly, with consequent increased efficiency, that town gas can best compete with fuel oil.

Sulphur dioxide can cause trouble to plants, principally by damage to foliage. The sensitiveness of plants varies with the species and with atmospheric and seasonal conditions, but concentrations of the order of 1 p.p.m. can cause serious damage.

Many plant growers are, therefore, unwilling to allow products of combustion of town gas to come into contact with such plants in their homes, and flueless heating of greenhouses by gas is generally excluded. Gas can, of course, still be used indirectly, for example by means of a hot water circulator and pipe system, but the potential advantage of cheapness and simplicity of direct heating is lost, and the load generally goes to other fuels.

Cost Consideration

However desirable it may appear, it is impossible to present from the utilisation side a list of monetary savings with which to offset the carefully calculated cost of sulphur removal. Many items are involved, some of which affect the basic design of appliances and their capital and maintenance cost. The magnitude of possible additional loads is particularly difficult to assess; and some important factors cannot be translated into terms of cash. Nevertheless, it seems desirable to draw attention to certain major points.

Reference has been made earlier to the necessity for using corrosion-resistant materials or protective finishes in vulnerable parts of appliances. It is not possible simply to compare the cost of a component in corrosion-resistant steel with that of the same component in mild steel, because basic design features might be changed if sulphur were eliminated. Condensation could be accepted in places where now it is not admissible, fins could be packed more closely, and so forth. On governed appliances, it might even be possible to consider reducing the present safety margin on combustion, leading to rather more compact appliances, for a given service, or to greater outputs from a given size. It may, however, be pointed out that corrosion-resistant steel costs six to eight times as much as mild steel. Hence, the works cost of a circulator containing 4 sq. ft. of steel is increased by about £1, and that of a balanced-flue space heater containing 8 sq. ft. by £2, solely on account of the special material. Such increases uplift the purchase price to the consumer by about 10%. Corresponding data for other appliances, which are not among the most vulnerable to sulphur corrosion, suggest an increase of the order of 5% in the ultimate cost to the consumer due to the use of corrosion-resistant materials. In the case of one small air heater, mild steel tubes have been replaced by chromised steel tubes with a four- or five-fold increase in 'life', but at an added cost that represents an addition of something like 5% to the ex-works cost of the appliance. In a larger air heater, the replacement of a mild steel heat exchanger by one of chrome steel increased the price by about 20%. As a further commentary on the cost of materials, a refrigerator flue extension in corrosion-resistant steel, the sole purpose of which is to direct the products of combustion from a 2.2 cu.ft. per hour burner from the top of the boiler tube out into the room above the unit, costs 10s.

Against Corrosion

In order to provide against corrosion, the body of a British instantaneous sink water heater contains 1 lb. more copper than its continental counterpart, costing about 1s. 6d. and the works cost of dipping in lead/tin alloy is approximately 1s. 3d. These two items together mean an added cost to the consumer (including the increased purchase tax) of several shillings.

If acid-resisting flue materials be used, it should be noted that a precast concrete flue block made of acid-resisting cement costs 40% more than a similar block in ordinary concrete. Any protective coating applied to a flue in situ is, of course, a straight addition to cost, and, in the case of some recent district installations, amounts to an overall increase of about 25%. Asbestos cement flue impregnated with vinyl acetate polymer also costs 25% more than plain asbestos cement. At the other extreme, to line an existing brick flue may cost up to £3 10s. per ft. run.

About 3 mill. instantaneous gas water heaters are installed in Great Britain. If a reduction of sulphur by half resulted in a reduction in maintenance by a quarter, the resultant saving would be of the order of £400,000, based on annual maintenance of 10s. for each appliance. These figures are thought to be conservative, but indicate the general order of magnitude.

This sum would be augmented by corresponding figures for those other appliances that at present require maintenance on account of sulphur corrosion. The maintenance of a central-heating plant is a much more expensive matter than maintenance of an instantaneous water heater. There are about 50,000 gas central-heating installations, and, while the cost of maintenance varies greatly with the size of boiler and complexity of controls, the actual cleaning is the biggest

factor. Reduction of sulphur by half might well save on the average £2 per installation, or £100,000 per annum over the whole country.

Balance-flue space heaters and air heaters are less significant numerically at the present time, but represent a growing maintenance item for future years.

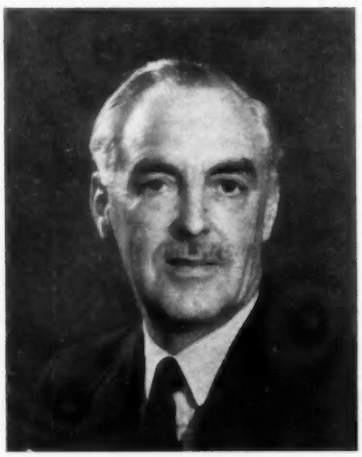
The preheater of a catalytic sulphur removal plant for industrial use consumes 3 to 4% of the total throughput, to which must be added a charge for maintenance and operation of the plant, and amortisation of the capital cost. The overall effect is to increase the cost of gas by nearly 10% if the plant is used continuously, and more if it is required for occasional use only.

Flueless space heating cannot be considered in some circumstances on account of smell or possible formation of acid condensate, and such loads may be lost to gas altogether. Similarly, in the industrial field the effect of sulphur oxides on the material being processed may preclude town gas from consideration. While the magnitude of these loads is largely a matter of conjecture, it must not be forgotten that any consideration of cost due to the presence of sulphur must take into account not only what is spent, but also a considerable loss of revenue.

It is impracticable to put a cash value on the effects on prestige of a reduction in sulphur, but to many this may be of first importance.

The case for sulphur reduction has been confirmed by the fresh data presented. If the intended expansion of domestic gas utilisation in the space- and water-heating fields is to be a major objective of gas industry policy, sulphur reduction must be treated as a matter of high priority.

3. Actions, Reactions and Side Reactions of Catalytic Sulphur Removal



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APART from the views and recommendations expressed throughout the industry, on the advisability and/or necessity of reducing the sulphur content of the fuel manufactured and sold by the Jersey Gas Company, Ltd., economic considerations were a major factor in reaching the decision that gas of low sulphur content must be supplied. As with all other undertakings, the incessant spiral of increasing costs has had its effect. These increases have been offset to some extent by the installation of modern plant at the works, but 'saturation point' was reached in this direction by 1955. Further increases in costs could be met only by increased gas and/or residual charges, or by additional revenue from increased sales.

As severe competition already exists with electricity and oil, any increase in the present gas charges would further restrict the activities of sales staff who, like many others have felt unhappy in selling flueless appliances, knowing that their use would be limited to the absolute minimum and in many cases lead to complaints of smell, and also to adverse publicity. The decision was therefore taken that 'we could not afford not to supply 'sulphur-free' gas.

The Company's gas, of 480 B.t.u. per cu.ft., from steamed continuous vertical retorts, contained on average:

	gr. per 100 cu.ft.
Thiophen	2.8
Carbon bisulphide ...	14.5
Carbon oxysulphide ...	16.8
Mercaptans	1.3
Total	35.4

The installation of an oil-washing plant would have led to the problem of disposing of crude benzole produced and since carbon oxysulphide would not be removed a resultant gas containing not less than 15 grains total sulphur per 100 cu.ft. could be anticipated. A Holmes-Maxted catalytic plant was installed and put into commission on May 25, 1957, since when the sulphur content of the gas supplied has varied between 2.8 and 5.9 grains per 100 cu.ft.

A description of the plant was published in the 'GAS JOURNAL' for March 19, 1958; gas flow diagram of the plant is shown in Fig. 1.

It was very gratifying to learn, from sales and distribution personnel, of the

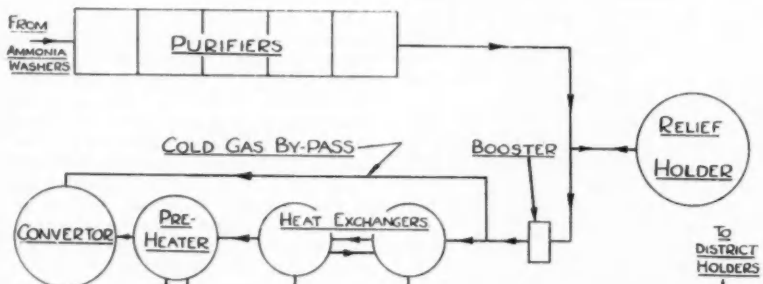

Fig. 1. Gas flow diagram of catalytic sulphur removal plant.

COMM. No. 525 AND DISCUSSION

95th A.G.M. — a 'Gas Journal' Abstract

consumers who, during the first few weeks of 'sulphur-free' gas, voluntarily commented on the great improvements they had observed. Gas sales during the quarter ending December 31, 1957, exceeded those of 1956 by 5.30%, although weather conditions were comparable. In one case, a hall radiator, which previously was used only when essential and never for more than 6 hours a day, was lit on October 9, 1957, and up to the present time (February 28, 1958) has continued to burn gas for 24 hours a day.

Comparable

In a particular case where an appliance was inspected and maintained four times per annum, deposits which weighed 44.6 g. accumulated in the three months prior to commissioning of the catalytic sulphur removal plant, but the same appliance after three months of 'sulphur-free' gas, only gave a deposit which weighed 5.5 g. The gas consumptions of the two periods were comparable. It is interesting to note that the weights of deposit in each case represented some 2% only of the deposits that could be produced by the sulphur compounds in the respective gases. From this, it would appear that in each case 98% of the sulphur dioxide formed passes through the appliance to flue and atmosphere.

Not one case of 'gum trouble' has been reported from the district since October 1, 1957. The very few cases dealt with between May 25 and October 1 were possibly due to deposits formed before the catalytic sulphur removal plant was commissioned on May 25. Some 20% of the gas fitters employed on the district have observed that a few appliance burners had required increased aeration, and plumbers on water heater service work have reported 37 cases of carbon formation on the bi-metallic strips of automatic valves at the point of impingement by the flame of the pilot-jet. The possibility of ferric carbonyl in the treated gas being the cause of the increased luminosity of non-aerated flames and of carbon deposits was considered, but the reports of other observers, that 'gas fire radiants do not acquire reddish brown staining so quicky as before,' somewhat discounted this possibility. The presence of nickel and/or molybdenum carbonyls in the treated gas could account for all the observations. In two trial samples, however, nickel and molybdenum were absent but iron was present, representing .028 and .013 grains Fe per 100 cu.ft. of the untreated and treated gases respectively.

It is suggested that the following reactions occur in the catalytic sulphur removal plant:—

(*a*) *In Heat Exchangers:*

1. $N_2 + 3H_2 \rightleftharpoons 2NH_3$.

(*b*) *In Convertor:*

2. Mercaptans + $H_2 \rightarrow$ paraffins + H_2S.
3. $CS_2 + 2H_2 = C + 2H_2S$.
4. $COS + H_2 = CO + H_2S$.
5. $C_{10}H_8 + H_2 \rightarrow$ hydronaphthalenes.
6. $NH_3 + C \rightleftharpoons HCN + H_2$.
7. $2NO + 4H_2 \rightleftharpoons 2NH_3 + H_2O$.
8. $C_nH_m + H_2O = C_nH_m + OH$.
9. $C_nH_{2n} + H_2 = C_nH_{2n+2}$.
10. $C_nH_{2n+2} + O_2 \leftarrow CO + H_2O$.
11. $H_2O + CO \rightleftharpoons CO_2 + H_2$.
12. $CO + 3H_2 \rightleftharpoons H_2O + CH_4$.
13. Nickel molybdate + $H_2S \rightarrow$ nickel thiomolybdate + H_2O.

(*c*) *In Regenerator:*

14. Nickel thiomolybdate + C + $O_2 \rightarrow$ nickel molybdate + SO_2 + CO.

The synthesis of ammonia was most unexpected and is discussed later. (Reaction 1.) Concerning the reduction of sulphur compounds (reactions 2, 3 and 4), it is interesting to note that the amount of carbon withdrawn from the convertor as deposit on the catalyst (6.7% by weight) agrees closely with that required by reaction 3. The absence of gum in the treated gas will be due to reaction 7 and also, probably, to the absence of highly unsaturated hydrocarbons such as cyclopentadiene and butadiene. (Reactions 8 and 9.) The reaction of oxygen and paraffin will add further water vapour to the 1.5 to 2.0% already present in the saturated incoming gas. (Reaction 10.)

It is suggested that the aliphatic unsaturated hydrocarbons of the C_nH_m group will be hydrolyzed to aldehydes and alcohols; or reduced to paraffins. (Reactions 8 and 9.) Gas from the outlets of the main purifiers, when passed through silver nitrate, gave an explosive white precipitate. Gas from outlet of the catch boxes gave much less non-explosive precipitate. Water vapour remaining in the system may then react with carbon monoxide according to reaction 11. The virtually complete removal of all water vapour from the system was unexpected, but it has afforded an explanation of the disappointing decreases in calorific value and carbon monoxide, and increase in carbon dioxide.

Although the catalyst in contact with thermocouples feeding signals to the controller is maintained at the set control temperature, the oxygen reaction does raise the temperature of the catalyst situated beyond the thermocouples, as is shown by the increase in temperature of the gas between 'inlet convertor' and 'outlet first catalyst pass.' The variable conditions obtaining in the convertor—due chiefly to the changing percentage of oxygen, varying gas throughput, catalyst temperature, etc., give rise to varying results at the plant outlet as is shown by comparing the calorific value and analyses of spot samples taken simultaneously at the inlet to and the outlet from the plant. The increase in carbon dioxide can lie between 0.8 and 2.4%, and the calorific value change between + 4 and − 8 B.t.u. per cu.ft. On average, however, it would appear from the increase in nitrogen, from 7.35 to 7.45%, that a decrease has occurred in the total volume of gas passing through the catalytic sulphur removal plant of 1.36% of the outgoing (metred) gas, the only loss of nitrogen from the system being by synthesis of an infinitesimal volume of ammonia.

Typical spot tests and analyses were taken during the short test runs, using air and pure oxygen for internal heating, instead of the external gas-fired furnace. From results obtained it is felt that a strong case can be made for the use of pure oxygen for both oxide revivification in situ and for heating the catalytic sulphur removal plant were adequate supplies available at a cost of 10s. or less per 1,000 cu.ft.

Simulated Conditions

A set of five new purifiers was first commissioned in October, 1956, the four existing boxes being destined to serve as catch boxes following the catalytic sulphur removal plant. Until May, 1957, when the catalytic sulphur removal plant was commissioned, these nine boxes worked in series, with sufficient foul gas by-passing the first five boxes to give a hydrogen sulphide content of the total gas entering the last four boxes of 25 to 30 grains per cu.ft., thus simulating the conditions anticipated when the catalytic sulphur removal plant was commissioned. No trouble was experienced in removing completely this hydrogen sulphide, irrespective of the four boxes containing new bog ore, new artificial oxide, spent or semi-spent oxide, and without addition of air for revivification in situ. Within two to three weeks of the catalytic sulphur removal plant being commissioned, however, these catch boxes began to cause trouble. Despite addition of air, reversing direction of gas flow from downward to upward, and frequent changing of oxides in boxes, hydrogen sulphide stains persisted. Microscopical examination

confirmed that bacteria were active. Oxides removed from these catch boxes, having done so little work that their gain in sulphur was of the order of 0.25%, were found to be putridly sour and alkaline. In no instance was an 'acid sour' oxide found.

At this stage, it was found that up to 3 grains per 100 cu.ft. of ammonia were being formed in the catalytic sulphur removal plant and passing to catch boxes. Steps were taken to eliminate or reduce the 3 grains of ammonia passing from the catalytic suphur removal plant to catch boxes. The circulation of sulphuric or of phosphoric acid of at least N/1 strength in the spray cooler removed all ammonia, but the acid attack on metal, even with inhibitors present, was too great for the process to be continued. The addition of an acid salt (e.g., ferrous sulphate or calcium phosphate) to the circulating liquor of the spray cooler reduced the ammonia to about .12 grains per 100 cu.ft. A continuous flow of fresh water through the spray cooler, and supersaturation of the gas at the inlet to the catalytic sulphur removal plant condensers by admitting steam, has maintained the ammonia at the inlet of catch boxes at about .06 grains per 100 cu.ft. By estimating the acidity of the partially-spent oxides now used in the catch boxes, it has been possible to forecast fairly accurately the period a particular purifier will operate before commencing to generate hydrogen sulphide.

In January last, due to a breakdown of the spray cooler, some 2 to 3 grains of ammonia passed to the catch boxes over a period of 18 hours. Seven hours after the breakdown, the first catch box, which hitherto had been perfectly clean, was passing approximately 2 to 3 grains of hydrogen sulphide. This stain was not removed by the second and third boxes, which were both known to be 'generators' of hydrogen sulphide of the order of .05 to .25 grains per 100 cu.ft., but was removed by the last taker, which had been recently charged with an acidic semi-spent oxide. The lead acetate test papers taken at the outlets of the first three boxes all had a 'glossy black' appearance. The addition of 1½% of air at inlet of catch boxes for 30 minutes sufficed to remove these excess stains, when the system reverted to its normal of first and last takers clean, second and third takers throwing off .05 to .25 grains per 100 cu.ft.

Infallible

Lead acetate test papers exposed over the surface of water previously saturated with foul gas taken from inlet to main purifiers had the familiar 'matt brown' appearance. When very dilute ammonium hydroxide was used, instead of water, the test papers were glossy black. Two days after this incident, froth (due to aerobic bacteria) appeared on the liquor dripping from the sealpot overflow of the condensate drain from the bottom of the first catch box, and three days later the catch box was generating hydrogen sulphide of 0.1 grains per 100 cu.ft. Froth has been observed at the condensate drain sealpots of each of the 27 purifiers (main and catch) whose generation of hydrogen sulphide has been studied during the past months, and its appearance is now regarded as an infallible indication that the purifier concerned will give a hydrogen sulphide stain within two to three days.

Following the many observations made since this catalytic sulphur removal plant was commissioned in May, 1957, of which the foregoing may be regarded as a brief summary, it is suggested:—

(1) The hydrogen sulphide 'generated' or 'thrown off' by an oxide derives from a genus of hydrogen sulphide-producing vibrio and/or from dissociation of ammonium hydrosulphide.

(2) The 'matt brown' or 'glossy black' appearance of a stained lead acetate paper readily indicates whether the stain has been caused by hydrogen sulphide or by ammonium hydrosulphide.

(3) Both hydrogen sulphide-producing vibrio and putrefying ammonia-producing vibrio are activated by traces of ammonia.

(4) Moisture in an oxide assists in retaining 'free' ammonia in the system.

(5) The admixture of alkalis with oxides will cause evolution of free ammonia, from the otherwise harmless fixed ammonium salts.

(6) Ammonium hydrosulphide will pass right through an oxide in which the free-ammonia concentration is sufficiently high to prevent dissociation of the hydrosulphide, the affinity of iron oxides and hydrogen sulphide being insufficient to cause dissociation. Should the oxide be neutral or acid, dissociation will occur and the normal iron oxide/hydrogen sulphide reaction proceed.

(7) Ammonium hydrosulphide and putrefying organic matter both have oxygen demands, and, if present in a purifier system, greatly increase the air admission required to maintain acceptable working efficiency of the system.

(8) The ammonia passed to inlet of main purifiers should not exceed the amount that can be retained as fixed ammonium salts by the acid constituents of the gas and/or oxide.

(9) Complete removal of ammonia from town gas should reduce the internal corrosion of holders, mains, services, and consumers' meters.

(10) The production of ammonia to the extent of some 3 grains per 100 cu.ft. of gas in the heat exchangers of the catalytic sulphur removal plants is in accordance with the Haber synthesis at the temperature (300° to 400°C.) and partial pressures of nitrogen and hydrogen obtaining.

(11) The disfigurement of gasholder lifts is caused by the deposition of dead aerobic iron bacteria, which had thrived on the surface of the tank water and in the film of water adhering to the sides of rising holder lifts. The amount of soluble iron in the water available to the bacteria is dependent on the acidity or 'corrosiveness' of the water.

COMMUNICATIONS Nos. 523, 524, and 525

DISCUSSION

The President: Sixteen years ago the Institution set up a committee to deal with this particular problem. Dr. H. Hollings was the chairman of that 1942 committee, so I have particular pleasure in asking him to open the discussion.

Dr. H. Hollings: 'The main technical facts concerning the removal of organic sulphur have been available to the industry for many years, and they are well surveyed and brought up to date by the papers before us.

'There is one technical detail in the paper by Mr. Clark and Dr. Spivey connected with the removal of sulphur which I would have wished to see treated a little more fully. I refer to the possibility of returning benzole to the gas, after the removal of sulphur from it. With particular reference to thiophen this possibility was studied in the laboratories of the South Metropolitan Gas Company as long ago as 1920. The process was to be applied to the gas stream after the extraction of carbon bi-sulphide by the Carpenter-Evans catalytic process which we have just been hearing about, and then the thiophen was to be separated from the benzole by a sulphonation process.

'Now that process never advanced, so far as I know, beyond the laboratory stage, for the simple reason that it was too costly, but in the intervening years much progress has been made in the processes of refining benzole by fractional distillation and otherwise, and although I am not very hopeful of the result, I suggest that either the authors or someone with intimate knowledge of benzole refining should deal with this aspect in more detail than we can find in the paper.

'Having still in mind the 1942 committee, I was particularly interested in those parts of the papers dealing with the cost of sulphur removal. The conclusion reached concerning the relative economy of operating the active carbon process with a shortened adsorption cycle is particularly interesting. The technical possibility was demonstrated at Beckton many years ago, but the circumstance that when re-examined in the light of present day costs this offers the possibility of a reasonable process, should be noted by all responsible engineers.

'Now at least two of the authors of these papers rather encouraged us to equate the cost of organic sulphur removal to the value of future expansion in total sales. Quite frankly, I think that is being a little too complacent. Now I enjoy a greater measure of freedom from responsibility than the authors, and so perhaps I may be permitted to be a little bolder and conclude by saying that as I see it, the writing is on the wall. You

Enjoying a chat between sessions, left to right, are: Mr. D. Lambie, Coatbridge; Mr. D. Ross, Arbroath; Mr. D. D. Melvin, Scottish Gas Board; Mr. W. Kirk, Greenock; Mr. R. Laing, Brechin; Mr. C. B. S. Mitchell, Kilmarnock; Mr. W. M. Gledhill, Stirling; and Mr. T. McDougall, Londonderry.

have to choose between giving up this lip service to sulphur, and treat the whole question with a greater sense of urgency, or else you may sit back and watch quite a part of your present load follow the lighting load.

Mr. C. H. Chester, C.B.E., Chairman, South Western Gas Board, said that anyone who made a worthwhile contribution to the solution of the sulphur problem as it affected the major portion of the gas distributed at present for use by ordinary consumers deserved the profound thanks of the gas industry.

The plant and the results of its operation to date, described by Mr. Wedgwood, represented such a contribution, and both he and his Company were to be congratulated upon their pioneering spirit and fortitude. 'As Dr. Hollings has just said, we may see the industry fret away.'

Mr. Chester continued: 'I was interested in what Mr. Wedgwood said: If it is only 5% = ¼d. per therm that is the cost of sulphur, a 5% increase obviously obtainable in Jersey with its warmer climate ought to be more easily obtainable in the climate of the North—I do not know about the South-West.

Pen and Ink

'It is difficult for those of us who have spent a considerable time in the gas industry, or even for anyone who has studied the history of its development, to consider a paper such as the one presented by Mr. Wedgwood without thinking of the great amount of work and even greater amount of pen and ink that have been devoted to the sulphur problem.

'Of course it is not new—Dr. Hollings and the President have mentioned the work of the South Metropolitan Gas Company, and the removal of organic sulphur compounds was dealt with in the early legislation of the gas industry, particularly that relating to the London Gas Companies, and as long ago as 1873 the Crystal Palace District Gas Company Act contained a sulphur clause.

'The removal or reduction in quantity of organic sulphur compounds by catalytic methods may perhaps be said to have started with the work of Dr. W. Siemens in the early 1870s, who designed a plant, which was installed and operated for a while at the Horseferry Road works of the former Gas Light and Coke Company. It was based on an earlier discovery that when gas, free from hydrogen sulphide, was brought into contact with heated surfaces, the carbon disulphide in the gas was converted into hydrogen sulphide, which could then be removed by conventional methods.

'One of the first processes for the removal of organic sulphur by destructive hydrogenation was based on the work of Carpenter and Evans of the former South Metropolitan Gas Company during the period 1906 to 1914, and their process was operated from about 1913 to 1939 and reduced the sulphur content of the gas to about 10 grains per 100 cu.ft. Since that time there have been important developments in the use and type of catalysts. For example, R. H. Griffith and the Gas Light and Coke Company used nickel sub-sulphide under oxidising conditions, while Maxted and Marsden investigated the use of metallic thiomolybdates, which were found to be very effective and have been developed for use in the type of plant described by Mr. Wedgwood.

'Most people, over the years, have agreed that, for a number of reasons, either the virtually complete removal or a very considerable reduction (say to 10 grains or less) in the organic sulphur content of towns gas is essential for the well-being of the gas industry. Various committees have been set up by the Institution of Gas Engineers, notably those which reported in 1936 and 1942, while the matter was also dealt with in the Heyworth Report in 1945, and of course the fortunate position of the American gas industry using, as it does, sulphur-free natural gas, was stressed in the Anglo-American Productivity Report issued in 1953. All these bodies of responsible people have made recommendations for sulphur-reduction or removal and no doubt those recommendations would have been implemented to a large extent, but for the post-war shortage of steel followed by the present-day conditions of financial stringency.

'However, if the competitive power of the gas industry is to be maintained, let alone increased, it is essential that sulphur removal be looked upon as an essential consumer service.'

Mr. Chester turned to specific points in Mr. Wedgwood's paper.

'On p. 8* he emphasises the point I have just made respecting competitive power.

Thiophen Content

'In the figures given for the distribution of organic sulphur compounds it is noted that the thiophen content of the 'steamed' C.V.R. gas is only 2.8 grains per 100 cu.ft., while the more usually accepted figure is at least 3.8 (cf. p. 13, I.GE. Comm. 175-37), but the figure given by Mr. Wedgwood may be a function of the type of coal carbonised. In any case, the result has apparently influenced his decision not to adopt oil washing for partial sulphur removal, no doubt because, apart from 'de-fronting,' the process is so dependent upon the economics of benzole extraction, which are possibly not so good in the Channel Islands.

'An interesting point is mentioned on p. 9, where Mr. Wedgwood states that boosters were installed to overcome the additional back pressure of the plant. It would be interesting to know whether the cost of their installation is included in the figures given on p. 28.

'The general procedure for control (p. 11) of the plant and regeneration of the catalyst appears to be very good and the plant has operated for a sufficient length of time to warrant drawing deductions from its behaviour.

'If it is accepted that sulphur removal

* Page numbers are given so that original texts may be referred to.

Mr. W. W. Scott and Mr. H. C. Armitt, both of R. & J. Dempster, Ltd., chatting with Mr. W. W. Chisholm of the North Thames Gas Board.

is vital and necessary, then it must be looked upon as a charge on gas production, although, of course, all possible steps should be taken to keep the cost at a minimum. The actual figure of 0.575d. per therm in 1958, as given by Mr. Wedgwood, would appear to be in line with the general trend of rising costs, because in 1949 (I.G.E. Pub. No. 344/157) Plant and Newling stated that the total cost for reduction of sulphur compounds to the order of about 3 grains per 100 cu.ft. was 0.20d. to 0.25d. per therm.

'Having noted the cost of sulphur removal, on the debit side of the account, one comes naturally to the possible credits, although here the calculation is not easy to make. Apart from the psychological effect that better and cleaner appliance behaviour has on consumers, there is the considerable reduction in maintenance costs which takes place when the sulphur content of gas is reduced. Much work has been done on the corrosion of appliances from the standpoint of their destruction, quite apart from any annoyance to users due to corrosion products being scattered about and, speaking in general terms, it may be said that the reduction in maintenance costs bears a linear relationship to reduction of sulphur content, and Mr. Wedgwood's experience would appear to bear this out.

Prevented

'Another very important additional advantage of the catalytic removal of organic sulphur compounds is that any nitric oxide present in the gas is hydrogenated to ammonia and water, and thus the formation of nitrogenous gum is prevented. This can have a valuable effect upon consumer service, although it is difficult to assess financially, but at any rate it should be set against the cost of sulphur removal.

'Mr. Wedgwood's contention that the unsaturated hydro-carbon figures given in Tables II and III in Section V are lower by about .75% than the actual values, is appreciated.

'It is interesting to note that the experiments on the detoxification of gas by the Maxted catalyst, as suggested on p. 21, have proved reasonably successful.

Mr. Chester said that apart from sulphur removal, the industry today was fully aware of the problems of high CO content in distributed gas, and in the new Dent hydrogenation processes the complete removal of sulphur and the substitution of the bulk of the carbon monoxide by hydrogen in a reforming chamber would be an integral part of any plant constructed.

Concerning the minimum oxygen content of gas, Mr. Chester was not at all sure that Mr. Wedgwood had examined his results in the light of all possible interpretations. It seemed that the solution of oxygen in liquid hydrocarbons was not apparently considered likely, but at the low temperatures employed in his experiments such a possibility could not be ruled out.

Notwithstanding, whether one agreed or disagreed with some of the findings in the paper, Mr. Wedgwood, by presenting the results of the operation and experiments associated with the catalytic removal of sulphur at Jersey gasworks, had made a very timely contribution to the knowledge that already existed on this important facet of gas manufacture. His addendum was interesting and thought-provoking, and even if it only stirred up a lively discussion, it would have served a useful purpose.

Mr. Chester concluded: 'In the next decade or two there will no doubt be a large development in high pressure gasification of oil and coal, the gas products from which will not contain any sulphur compounds; but there will be for many decades still a large proportion of gas made by our traditional methods in existing modern works which, for many reasons, will have to continue, so that there must be room for the installation of such units for sulphur removal in order that a gas containing a very small quantity of sulphur compounds may be distributed to the immense benefit of gas distribution and sales services in general.

'The tools are at hand, and the industry must use them in the ensuing few years.'

Mr. R. N. Bruce, Deputy Chairman, North Thames Gas Board: 'There is a wealth of useful and interesting material in the trilogy which has been presented today on the subject of sulphur in the town gas, and I should like to emphasise a few of the many points which have been raised.

'First, it has been shown by Mr. Purkis beyond doubt that there is a direct relationship between the organic sulphur content of gas and corrosion of appliances on the district, particularly the instantaneous water heater. This latter appliance is one which we all hope will continue to increase in numbers on the district, as it has considerable advantages in day-to-day use over its competitors and gives us a good gas load. It is, however, expensive to maintain, and anything that can be done to cut down this expense is worthwhile.

'On p. 22 of Mr. Purkis's paper he refers to the fact that the North Thames Gas Board have decided to put theory into practice and to alter the time interval between routine maintenance visits, dependent on the average sulphur content of the gas. It may be of interest to you to have some more details of what we intend to do.

Sulphur Levels

'Divisional managers throughout the whole of our area are at present checking sulphur levels throughout their divisions. As you will appreciate, as all our works are inter-connected by grid there may be varying sulphur levels both from day to day and certainly seasonally throughout the year, but on an average one can estimate what these levels will be as a broad pattern. Having checked these, it is the intention that those areas which it is estimated will average lower than 15 grains sulphur per 100 cu.ft. will be designated, and the inspection periods reduced from the present levels for non-condensing water heaters of one inspection and clean per annum to one in two years; and for condensing water heaters, one inspection and clean every other year, to one in four years; the rest of the area, at least for the present time, being kept on existing inspection schedules.

'Checks of sulphur levels will be made from time to time to see that the pattern has not changed, and a sample of heaters will be specially inspected on an individual basis to ensure that theory and practice correspond.

'As this is a new practice it is necessary that all concerned with carrying it out should be aware of the object, so

that reference will be made to it in foremen's courses and fitters' refresher courses at Watson House. Futhermore, special attention will be directed to the efficiency of the cleaning operation and to the correct setting of appliances.

'By cutting down without loss of safety our water heater inspections in this way, some of the possible £400,000 per annum saving, estimated for the industry as a whole, and referred to by Mr. Purkis on p. 30 of his paper, will be achieved. Such savings will be in line with those mentioned by Mr. Wedgwood on p. 14 of his paper, where the reduction of fitters' time spent on maintenance has been reduced by over 40%, a really worth while economy.

'My second point refers to the fully condensing bath water heater mentioned on p. 7 of Mr. Purkis's paper. Personally I feel that even more attention should be given to this type of appliance because it is not so susceptible to high sulphur gas, and its efficiency can be increased to over 90%. Furthermore, fully condensing water heaters of reasonable gas rates, particularly if the sulphur content is low, might well be installed without flues thus giving dual economies and putting them in an even better competitive position with some electric water heating appliances. Any development on these lines which can be accelerated by work done by appliance manufacturers or at Watson House, I am sure should be encouraged.

'Thirdly, on p. 5 of their paper Mr. Clark and Dr. Spivey refer to the limits of hydrogen sulphide removal, a point which the President also touched on in his address this morning. It appears to me that this is a case of what I would like to call asymptotic insurance; in other words, that cost of the extraction of small quantities of material does not follow a straight line relationship, as a result of which it becomes considerably more expensive to remove last traces. This is particularly true of H_2S removal.

Surprised

'While it is agreed that a limit must be placed on hydrogen sulphide permitted in town gas, there is no evidence to show that hydrogen sulphide up to 5 parts per million has *per se* any injurious effects, either from a corrosive point of view, or from smell. The quantity of sulphur dioxide produced by combustion of the 0.2 to 0.7 parts per million (the present tolerance) is small compared with the amount of sulphur dioxide produced from gas having an organic sulphur content of 20 grains per 100 cu.ft. I do not know if you have worked out the relationship between 5 parts per million of H_2S and SO_2 produced from it and 20 grains of organic sulphur per 100 cu.ft.; those of you who have not would be surprised what the ratio is. Therefore it appears that if there could be some relaxation of the limits for hydrogen sulphide, savings of purification costs could be achieved which might then well be expended on reducing organic sulphur in gas, to the interests of the industry as a whole.

'Lastly, on p. 17, Mr. Clark and Dr. Spivey mention the importance of benzole extraction for reducing sulphur content. Both Dr. Hollings and Mr. Chester have mentioned this point, and I would like to emphasise the point that thiophen is the nigger in the woodpile. I would support the opinion expressed by the authors that the revenue from benzole is likely to decrease. The time may well come, if it has not already come, when, apart from its essential use in removing sulphur from gas, extraction of benzole may not be worthwhile. The establishment of the economics of benzole removal and its relationship to its gas enrichment value is most important. I believe we may see the day when it is returned to the gas for this purpose, but there remains the problem of thiophen which is difficult to remove. I would therefore urge the authors to continue their work on this problem, particularly on the lines of the use of zinc oxide catalysts to which they refer on p. 14 of their paper.

Sooting Up

'However, the life of a gas engineer is never a dull one, as no doubt the reintroduction of benzole into the gas stream will create a problem for Watson House and their colleagues in the shape of the sooting up of appliances, especially gas fires of the luminous burner type. It may be that they should now be turning their attention to this point.

Mr. J. E. Davis, O.B.E., Chief Technical Officer, South Eastern Gas Board, said: 'Reading these three papers again, I wondered why the tremendous amount of work Mr. Purkis has put in was necessary. Who is it we are trying to convince? Is it ourselves, for certainly the district staff do not need convincing. Is it the public? I think they hardly even as much need convincing that sulphur is an objectionable thing. I wondered if it was the cost accountant who had to be satisfied that it will pay off. I recall some of those road signs that tell us 'Bad driving kills' and 'Good driving pays.' I wonder whether anybody worked that out mathematically, or whether it is just commonsense.

'Mr. Purkis has collected this vast amount of information together. We are grateful to him for the precision of his work, but we really ought to have known it before.

'Mr. Clark and Dr. Spivey have brought together in a most convenient form the knowledge on sulphur removal processes. There is no excuse for anybody who does not know what is available. I was looking at some of the figures here for the types of sulphur compounds. When my former Company was using the catalytic process for the removal of organic sulphur, we did not know nearly so much—we only knew two kinds of sulphur, that which could be removed by a catalyst, and that which could not. We assumed the latter was thiophen.

Dr. Hollings has referred to the elaborate attempts to deal with thiophen. We could not contemplate benzole extraction because we thought the illuminating power of benzene in the gas was important. It is not, today; that side is very much simplified. There are a number of glimpses of what might be, with better processes yet to be. I do not think they should deter us for a moment in doing the best we know now.

'There were dark hints about the fifty-fifty arrangement with the Exciseman: I think there we must be careful. There is no reason to let ourselves into an awkward situation in that respect.

'At the end of their paper they gave figures for the total cost of removing sulphur. Parliament, in passing the South Metropolitan Gas Act, 1920, evaluated a low sulphur content at an additional ¼d. per therm. Allowing for inflation, I think that is about right today, and the arguments as to whether it ought to be ¼d. or ½d. or .8d. I suggest are irrelevant.

'Then I come to Mr. Wedgwood's paper. The resources that the authors of the first two papers had at their disposal were enormous. Mr. Wedgwood had not anything like it. He has, however, displayed enormous ingenuity, particularly with the side reactions. It would be a great pity if the fact that, as he himself admits, he has not completely proved all those side reactions, were allowed to detract from the value of his paper and his work. The important thing in that paper is the actions and reactions chosen to interpret the action of his Company, in doing something about it, and the reactions of consumers to what they have done.

Mr. Davis paid tribute to 'a very fine chemist, my friend and colleague, Harold Stanley, who by his coming retirement will probably find this his last Institution meeting while still actively working in the industry. He has made a great contribution to this, and I think it was he who first showed that metallic sulphides could still be used as hydrogenation catalysts. I do hope he will not feel, as he retires, "is not this where I came in?"'

Mr. N. Hudson, Chief Commercial Officer, North Eastern Gas Board, said that 'the two papers by Mr. Clark and Dr. Spivey, and Mr. Purkis, were an historical review of what had been known for a long time. There is a little new information in this 1958 edition.

Quantitative Basis

'Is Mr. Purkis right in saying that one possible reason for the apparent lack of success in bringing about a substantial reduction in the sulphur content is the difficulty of arranging a quantitative basis for a good result and assigning a cash value to it? It would appear from what we have heard this afternoon, and for many years recently, that that is the obstacle. If there was a profit in it, without any doubt I think we should be taking action now, and we should have started a long time ago.

'What do we do to prove the cash value of those benefits? I think as far as that point is concerned we should congratulate the Jersey Gas Company on

taking a very definite step last year to try to prove this point. I think they had a detailed figure of what it would cost to operate, and it is those benefits they are hoping to obtain that will offset those costs. I hope you will forgive me if I say I have no doubt they will offset those costs. They will not do it the first year, but having adopted a catalytic plant, they will save costs not only on maintenance of water heaters and space heaters but on the maintenance of meters because of the No. 7 reaction which does away with nitric oxide. They will also save indirectly, by the increase in their gas sales.

'They have faith, and I welcome this opportunity of offering my congratulations to everybody concerned with the Jersey Gas Company for having had the faith and courage to take this step. I think it will not be long before we have many similar instances in this country.'

Mr. K. W. Francombe, Whessoe, Ltd., Darlington, said that the authors Mr. Clark and Dr. Spivey had asked him to say a few words about their paper.

One could only think it was rather bad luck that the North Thames Gas Board's Harrow gas contained 10.2 grains of thiophen (Table 2). Had it contained only 4.5 grains as at Mirfield, or 2.8 grains as Mr. Wedgwood reported for Jersey, in the last case the outlet sulphur would have been down to about 6.2 grains by catalysis alone.

Meaningless

Mr. Francombe continued: 'I am glad that in their cost summaries the authors have usually (although not always) rounded off the cost per therm to the first decimal place. The figures will vary so much with the capacity of the plant and the particular distribution of the sulphur compounds, that any greater degree of accuracy is quite meaningless. The highest figure they have quoted is for a two-stage removal system at 0.8d. per therm, whereas Mr. Wedgwood's single stage system costs 0.9d. per therm before deducting the credit for reduced maintenance of appliances.

'Might I suggest that in most circumstances the best start to make on this problem would be by installing activated carbon plant at an estimated cost of 0.3d. per therm (Table 7). With 8.5 grains slip, the gas would then be just as sulphur free as paraffin (Table 1), and just below the threshold of smell perception, in the circumstances outlined on p. 6. If slightly better cleaning costing 0.4d. per therm can be afforded, then employ the carbon plant with a shortened adsorption cycle. Provide branches for a secondary cleaning system in case this primary system encourages one to go a stage further in the future.

'If the reduction in c.v. is an embarrassment, then replace the benzole therms with commercial butane which the authors state need cost no more than manufactured gas and which is itself sulphur-free. Such a scheme would take us a long way in the right direction without significant increase in the cost per therm, especially when the credits for reduced maintenance and increased space-heating sales are deducted from the authors' figures.'

Left to right: Mr. J. S. Marshall, Lincoln; Mr. W. A. Pask, Grimsby; and Mr. A. Facer, Pontypool.

Adding a few words about Mr. Wedgwood's paper, Mr. Francombe said he was reading it in the train when he came across some of what he might call Mr. Wedgwood's 'hydrogenation bombs,' which aroused him so, that he nearly pulled the communication cord!

'Just to touch on a few of these, I gather Mr. Wedgwood believes that ammonia should be reduced to below 1 grain per 100 cu.ft., even on purifiers dealing with 950 grains sulphur gas, to avoid the production of the St. Helier bacteria. Having been brought up on 3 to 10 grains ammonia to purifiers this was the first shock. However, I was delighted to read of the ensuing 64% sulphur in spent oxide, as I have a vested interest in this set of purifiers.

'Then the synthesis of ammonia from hydrogen and nitrogen in common or garden heat exchanger tubes was another shock! The fact that the resultant 3 grains of ammonia was not welcome in the catch boxes was also a surprise, as I have often had to think of how to add ammonia to producer gas or coke oven gas purifiers when no ammonia was present. This makes me think that the N.T.G.B. catalytic process, which oxidises the organic sulphur to SO_2, and hence mops up any synthesised ammonia, may have a distinct advantage over those systems which hydrogenate it to H_2S.

Mr. R. S. Longhurst, Carlisle; Mr. A. H. Woods, Liverpool, and Mr. H. J. Blakeley, Watford.

Completely Dried

'I gather that a catalytic shift-reaction between water and carbon monoxide, with production of hydrogen and carbon dioxide, means that the Jersey gas is completely dried. If the spray cooler were eliminated, then perhaps the system could be credited with the cost of gas-drying, in addition to sulphur removal? This might retrieve the somewhat dis-

appointing economics reported in the paper, amounting to no less than 0.9d. per therm until a credit is claimed for reduced maintenance of water heaters. As there is no item in the costs for fines for failing to maintain the statutory H_2S limit, I assume the last catch was always operated bacteria-free while the researches proceeded.'

Mr. F. G. Pyper, Chief Engineer, East Midland Gas Board: 'I do not think we can hope to get a gas with under 5 grains of sulphur per 100 cu.ft. for some time. The amount of plant installed to obtain this standard throughout the country is great. In the East Midlands Board, we have been looking very carefully into this problem, and except for that part of the area that lies in the East Midlands coalfield, we are sending out gas with a sulphur content not exceeding 25 grains of sulphur per 100 cu.ft. In the Nottingham and Derby area, however, we do find the sulphur in the gas is 30 grains or even considerably over 30 grains. Coke gas purchased contains 30%.

'We have been promised the co-operation of coke oven operators in improving this, so there may be a general reduction if we carry out the schemes within our own doors. In this part of our area we send out a calorific value of 480: It is intended to increase this to 500 in the near future.

'As to comparison of cost, butane is much more expensive. Probably the cheapest means of raising the c.y. is the use of light petroleum. In Sheffield and Rotherham the problem is different; here 85% are industrial consumers, most of whom are not conscious of sulphur content, but all are conscious of price. We have almost entirely static carbonising plant.'

Mr. N. Barnes, Chief Development Engineer, Ascot Gas Water Heaters: 'I have some comments referring to the design of instantaneous gas water heaters and variations thereof, such as central heating units in which the essential component is the finned heat exchanger. Such appliances are important for two reasons —the need to develop our appliance business on international lines, these appliances are established in Europe, and have a potential in North America; and the need to compete with other fuels. These appliances are outstanding as a means for providing a large heat input on a piped fuel supply.

'From the work with which I have been concerned I endorse Mr. Purkis's description of the state of development of bodies and heat exchangers with respect to design. Copper is evidently the best material known at present, except for its susceptibility to corrosion by sulphur compounds. This has led to the development of alternatives, to provide finishes on copper which do not provide a basic solution, and the use of aluminium and stainless steel, which have their own particular disadvantages.

Perspective

'If a definite policy for the reduction of sulphur in British gas could be established, it would have two important effects on the design of the appliances in question: It would avoid excessive commitments on the establishment of a design specifically arranged to deal with a high sulphur gas which at some future date would be rendered obsolete by the abolition of such a gas; and it would allow a concentration on the development of the optimum design for low sulphur gas.'

Mr. F. Broomhead, W. C. Holmes & Co., Ltd.: 'The case for the catalytic process in preference to intensive oil-washing was overwhelming in view of the high carbon oxysulphide content of the gas being manufactured, for on the basis of the analysis given on p. 8, the latter process could not be expected to reduce the total organic sulphur below perhaps 18.0 grains per 100 cu.ft.

'On p. 8, Mr. Wedgwood comments that catalytic treatment was not expected to remove thiophen. Our experience shows that thiophen is reduced by approximately 20% by Holmes-Maxted catalyst, and plant performances are estimated accordingly. It may be of interest to quote details of an organic sulphur survey carried out in Jersey before the plant was ordered.

Pressure

'A series of analyses were carried out in December, 1957, after the plant had been in operation for approximately seven months and averaged a thiophen removal of 19%; CS_2 removal of 92% and COS (and mercaptans) at 93.5% giving an overall reduction of 85.5% from an inlet of 33.6 grains/100 cu.ft. to 4.9 grains at the outlet.

'Mr. Wedgwood has indicated on p. 11 that the maximum capacity of each plant is 90,000 cu.ft. per hour, but it should be noted that this limitation is set very largely by back pressure considerations. This factor apart, we have reason to believe from past experience that the throughput could be increased very considerably without serious loss of sulphur removal efficiency by increasing the rate at which catalyst is removed, regenerated, and recharged.

'Capital charges represent the largest single item, but any adjustment will probably have to be confined to the final contribution of 0.212d. per therm covering catch boxes, building and final gas cooler. It is possible for catch boxes to be eliminated by a set of gas connections enabling the C.S.R. plant to be rotated within the main purifier system, the building restricted to bare essentials, and the final gas merely spray-cooled to condition it for return to the main purifiers.

'By such modifications, this figure of 0.212d. might possibly become 0.1d., and the overall final process cost reduced to about 0.64d. per therm.

Active Carbon

'Considerable emphasis has been placed on the possibility of achieving up to 80% organic sulphur removal by the active carbon process. While this has been proved at Beckton where presumably mixed horizontal retort and coke oven gas is being handled and where therefore the COS will be low and the thiophen and CS_2 comparatively high, would this performance be obtained at, say, Jersey or any other C.V.R. works where the COS content would be appreciably higher than at Beckton? Would the active carbon process be appreciably superior to the intensive oil washing process at Beckton from the aspect of organic sulphur removal efficiency?

'The process cost in Table 6 and the comparisons in Table 7 will be extremely useful for reference purposes, and it is noted that Table 6 shows the total present day cost for the Homes-Maxted process at 0.41d. per therm, representing perhaps a capacity of 10 mill. cu.ft. per day. With gas connections to bring the plant within a rotatable set of purifiers, this cost would increase to 0.44d. which compares with 0.6d. in the table.'

Mr. W. G. Phillips, General Manager, Norwich Division Eastern Gas Board, said he did not think that the two aims —that gas should be of a lower sulphur content and its price competitive—contradicted one another.

Mr. James Emerson, Development Manager, Main Water Heaters Ltd.: 'As manufacturers of water heaters, my firm has a live interest in the problem of flue gas corrosion, and in our laboratories we have done a certain amount of work on the subject. The natural choice of material for finned heat exchangers, at least for instantaneous heaters, is copper. We all know that using copper some form of protection is indispensable.

'If we confine ourselves to metallic protective coatings, we can divide them roughly into two categories. In the first place we have hot dipped coatings in which adhesion to the basis metal is effected through the medium of an alloy layer between the coating and the copper. The second type comprises coatings without this alloy layer such as may be produced by metal spraying or by electro-plating.

'This separation seems somewhat arbitrary but is justified by the way in which corrosion takes place. In both cases it is the copper which corrodes. Dr. Booth showed in his paper that the end product was largely copper sulphate. It is not difficult to find metals which can be plated or sprayed, and which in themselves are virtually unattacked, but adhesion to the copper is hard to procure. The appearance of units treated in this way and then subjected to life test usually shows that the coating has flaked off bodily from the underlying copper.

'When we turn to hot-dipped coatings, a life test on these produces a bloom of copper sulphate on the fin surface, but after washing out at the end of a run the coating is apparently intact. This state of affairs indicates that the corrosive gas is here attacking copper atoms which are present in the coating and are probably also migrating through it.

'The protection of traditional materials or the employment of alternative materials and the various other methods resorted to are to be accepted at best as merely palliatives to a disease for which we know the correct fundamental treatment and the operational procedure.'

95th A.G.M. — a 'GAS JOURNAL' Abstract

COMM. No. 522 AND DISCUSSION

MATERIALS and STRUCTURES

by

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ENGINEERING skill and ability, to be complete, should be based on at least three fundamental aspects of approach. These are: Theory, practice and economics. While theory and practice can be related to any type of material or structure the engineer may choose, a final survey based on economics serves as a very valuable check on the economical use of the materials specified or the type of structure chosen. The engineer cannot, therefore, dissociate himself from cost in any project. The object of the paper is to present the results of experience gained in the gas industry relating to the economic use of structural materials and the scientific design of gasworks structures.

Special Conditions

Before any structure can be properly conceived and economically designed, the fullest consideration must be given to the following factors, generally in the order in which they are tabulated:—

(i) Environment and working conditions.
(ii) Choice of materials and durability.
(iii) Maintenance problems and cost.
(iv) Constructional methods.
(v) Present and future loading.

Some of the special working conditions encountered in gasworks practice require as much consideration in the design stage as may be necessary for the structural calculations. Typical special conditions are:

(1) *Temperature* in tar and liquor tanks, cooling and quenching plant, retort house floors, flues, etc.

(2) *Abrasion* in hoppers and mechanical handling plant.

(3) *Fire risks* in coal and coke storage plant, etc.

(4) *Impact* in bunkers and mechanical handling plant.

(5) *Chemical attack* and disintegration in tanks, purifiers and chemical plant.

Protection from damage due to these factors can be obtained by the use of special materials of construction, special bonding cements, protective paints and hard linings.

It is suggested that more detailed consideration should be given to the choice of materials, not only in the case of an individual structure, but also in the final integration of the whole project. As an example of the principle involved, each major gas-manufacturing scheme should be broken down, not only into the various trades and professions, but also into the different materials used, so that the whole scheme may be carefully balanced and co-ordinated both from the constructional and operational points of view.

It is important to realise that first costs do not always represent the total financial liability in respect to a particular item, and that later maintenance charges may completely alter the respective merits of two proposals

Much of the work involved in maintaining a structure in first class condition throughout its working life lies in one or more of the following items:—

(1) Cleaning and painting structural steelwork.
(2) Repairing or replacing sheeting.
(3) Reglazing windows and replacing sashes.
(4) Making good surface defects in concrete work.
(5) Cleaning roofs, gutters and downpipes.
(6) Repairing or replacing damaged members.

If a study is made of the frequency of repair needed on any of the above items, it will be found that a number of common causes can be detected.

Materials of construction and constructional methods are inter-related. Factors governing the selection of materials include:

(*a*) Isolated structures of great height.
(*b*) Erection of structures over inaccessible areas such as docks, rivers, or railway tracks.
(*c*) Time available to carry out the work.
(*d*) Restrictions as imposed by relations with the general public.

Generally speaking, structures erected at a considerable height from the ground should be light in weight, prefabricated in sections and easy to lift into place. For these reasons, structural steelwork is widely adopted for this class of work, although reinforced concrete and prestressed concrete are being more and more widely used in these circumstances, for, while the site may be inaccessible for erection purposes, it is equally inaccessible for subsequent maintenance, a factor that is considerably reduced by the use of concrete construction. Consideration must always be made, not only of present construction, but also of possible additions and alterations.

Engineering processes are always changing, and an industry such as the gas industry must take advantage of every new process or mechanical device as soon as practicable in order to maintain its competitive position in relation to other industries. This implies frequent changes accompanied by modifications to plant and the structural work associated with it. Provision for such circumstances can be made in several ways, depending upon the type of structure involved. Where buildings are involved, such portions as may be subject to later modifications may be constructed in steelwork, while the more permanent sections of the work should be in reinforced concrete.

Overhead Gantry

Prototype plant, which is often subject to continual variation and modification, even during the initial erection period, should be accommodated in the open or in existing buildings wherever possible, and supported on steelwork, which can be more readily assembled, dismantled and re-used than most other structural materials. Where considerable change and development is expected over a period of years in the general works services and supply mains, it is possible to construct a general purpose overhead gantry connecting all the major power

plants and focal-points together so that the re-routing of steam mains, electric cables and water services can be made without recourse to any structural modifications. This system, incidentally, also has the advantage of simplifying the general servicing and maintenance that such work always requires, and at the same time presents for immediate attention any sudden breakdown or failure that may occur.

Brickwork to be erected in the normal environment of a large gasworks requires to be given some very considerable thought on account of the following points:—

(*a*) Rough surface texture holding dirt, dust and other chemical impurities.
(*b*) Absorptive properties and need for damp courses.
(*c*) Low strength to weight ratio.
(*d*) Structural limitations in form.
(*e*) Mortar for bedding and pointing.
(*f*) Expansion and contraction characteristics.
(*g*) Erection time and cost.
(*h*) Resistance to atmospheric deterioration.
(*i*) Lack of structural rigidity.

Normally construction in brickwork is limited to walls, piers, buttresses and arches where the no-tension theory can be applied economically.

High Temperatures

The properties of concrete are widely known, but there are certain of its lesser known characteristics which may be of importance in gasworks constructions. Since fires in fuel or ash bunkers are not uncommon, the effect of high temperatures on normal Portland cement concrete and on steel reinforced concrete are important.

The limiting working temperature for plain concrete is about 250°C. Above this temperature, serious falling off in strength will occur. Normally, the designer would have to consider the effect of thermal stresses long before this figure were reached, and, in the case of differential thermal stresses, the fullest consideration would have to be given even under normal atmospheric conditions.

So far as reinforced concrete is concerned, being a composite material with the properties of its individual constituents differing appreciably, it is essential that the designer should give the fullest consideration to the effect of elevated temperatures both on the aggregate and the cement matrix, as well as on the reinforcement. In the case of steel reinforcements, both hot and cold strengths are of importance to the engineer, the former during the period of elevated temperature and the latter as a measure of residual strength. As the ultimate strength of concrete cannot exceed that of the aggregate of which it is composed, it is important to consider to what extent the various aggregates can affect the ultimate resistance of concrete to high temperatures.

Tables are given in the paper showing the characteristics of various types of aggregate. For steelwork structures, the advantages of tubular construction in gasworks practice are not always sufficiently realised.

Among some of the more important advantages of this type of construction may be mentioned:—

(*a*) Reduction in dead weight by comparison with traditional steelwork.
(*b*) Reduction in surface area up to about 25% or more, by comparison with sections of the same weight in traditional steelwork.
(*c*) Reduction in surface cleaning and painting, with a proportional reduction in maintenance costs.
(*d*) Less opportunity for damp and dirt to collect on the structure.
(*e*) Fewer gusset plates, and absence of rivets, give tubular structures a simpler and cleaner appearance.
(*f*) Curved sections may be used more easily than with traditional rolled sections.
(*g*) Tubular members may be prestressed and their structural performance enhanced accordingly.
(*h*) Wind resistance of the circular sections is reduced to 0.6 of that on a flat surface.

Provided the ends of all tubes are effectively sealed, the durability of the final painted structure is probably better than that of a structure composed of angle or channel members with gusset-plate connections. In many cases, the sharp edges of gusset plates, the cut ends of structural sections and the sharper arrises of angles and channels are partly responsible for the initial breakdown of the paint film at these points, and for the corrosion that inevitably follows. Tubular members, therefore, while facilitating painting, also obviate many of these defects at the same time. The use of large diameter mains as constructional members can often be undertaken as an economical measure. Such mains may be incorporated as beams, arches, and tension members.

Special steels are sometimes used for constructional purposes and, so far as their use is related to obtaining higher strengths and greater uniformity of physical properties over a wider temperature range, their adoption is worth consideration, but if it is desired mainly to combat corrosion, it is generally more economical to use some form of surface treatment rather than to use expensive alloy steels. The extended use of aluminium alloys for building purposes has spread to almost all branches of engineering.

Major Asset

By comparison with structural steelwork, its higher strength to weight ratio is, of course, one of its major assets. Apart from structural frameworks, certain relatively large parts of a building, such as the roof or walls, are provided primarily as a form of protection for the operatives against the weather and also to maintain good clean working conditions, as constant as possible, particularly so far as temperature and humidity are concerned.

In such cases, construction involving the use of aluminium alloys would be considerably lighter than either structural steelwork or concrete, and would, therefore, enable the sub-structure and foundations to be correspondingly lighter.

While it cannot be said conclusively that this form of construction is, at present, cheaper, item for item, than the more conventional methods, there may often be secondary factors whereby substantial savings in cost can be made.

Larger structures, notably long-span bridges, could profit appreciably by the higher strength to weight ratio in so far that the ratio of pay load to dead load would also be proportionally higher. For the types of structure used by the gas industry, the main advantages would lie in the greater amount of prefabrication possible, together with ease of transport and reduction of site handling problems.

The ability of aluminium alloys to withstand atmospheric corrosion is a point of vital interest to the gas industry. Not only does this enable the normal maintenance costs to be reduced, but it also obviates the need for the initial coats of paint so essential to all structural steelwork. This property may, in some cases, be more valuable to the industry than any other of its qualities. It is important, however, that the conditions under which it will be expected to function should be carefully studied, since it is always possible for local corrosion to occur as a direct result of electrochemical or purely chemical conditions.

A number of long-term corrosion tests have been carried out in America on various types of aluminium alloy. Some of these tests relate to conditions similar to those experienced on many gasworks in this country, and are, therefore, of interest.

From among the conclusions drawn from these tests may be quoted the following:—

(*a*) The effects of atmospheric weathering, when based on measured depths of attack and loss of tensile strength, generally decrease with the time of exposure, and are therefore self-limiting.
(*b*) The percentage loss of strength due to corrosion diminishes with increase of metal thickness.

Tables and curves are given showing physical properties of the principal structural aluminium alloys.

Timber construction is becoming increasingly popular although its use by the gas industry is subject to certain limitations, presumably on account of the fire risk. The use of selected timbers for structural work is, however, of considerable interest, chiefly on account of certain developments, which make its use more consistent and durable. These factors may be listed thus:—

(*a*) The development of proper mechanical methods for connecting members together and forming joints.
(*b*) The introduction of a system of stress grading.
(*c*) The increase in the range of timbers available.
(*d*) Developments in the use of glued laminated construction.

Each of these factors contributes to a technique whereby a wide range of struc-

tural forms can be chosen and executed where no timbers of great length of excessive section are necessary, and where variations in grade of timber may be specified to suit the type of stress to be carried by each part of the member in question. Durability under certain circumstances may be even better than that of mild steel or concrete, although its capacity to absorb moisture or other undesirable effluents is a considerable disadvantage.

While the use of rubber in the field of mechanical engineering is too well known to comment upon, the material in one form or another also possesses certain physical properties that, for the civil and structural engineer, are not without interest.

Among the more obvious uses are the following:—

(*a*) The absorption of impact forces.

(*b*) The damping of vibration in buildings.

(*c*) For bearing pads for structural work.

(*d*) In forming ducts in concrete and pneumatic cores for a wide range of other works, such as sewers and ventilation shafts.

(*e*) For lining shuttering for concrete work, lining mixer drums, and other engineering plant.

Deformation

In cases (*a*), (*b*) and (*c*) above, the rubber will function either in direct compression or in shear. Under this type of loading, large deformations are produced and full consideration must be given, therefore, to its deformed shape both in making provision for such change of shape and also in limiting the deformation. Excessive deformation will cause rupture of the material, while restriction of deformation will reduce its efficiency.

The paper proceeds to a detailed study of some of the more important aspects relating to structures, the main items of plant being subdivided into (a) buildings, (b) open framework, including gantries and trestles, (c) gasholder tanks and foundations, (d) miscellaneous structures.

Considerable variations exist in the size of the building shell provided to accommodate retort installations, carburetted water gas plants and coke-grading plants. The difference in some cases is so pronounced that the engineer is for his own satisfaction almost forced to make further investigations. In doing this, it is essential to go right to the beginning of the problem and ascertain that the need for a building has been properly established in the first instance.

This is an important question, because many installations today can operate quite effectively and efficiently in the open and are, of course, designed for such conditions.

Moreover, as the general tendency for such equipment is to increase in size, so also will the cost involved in housing this equipment rise to proportions that may well be unjustified. It is interesting to note that both the new oil-gasification plant at the Isle of Grain, Kent, and the refinery gas reforming plant at Romford, Essex, are unhoused.

It is only fair to say that, in certain localities, it is imperative to house plant that would otherwise remain in the open, and the final approval of materials and structural form may also rest with authorities outside the gas industry. In these cases, additional expenditure may be necessary to comply with the requirements of local authorities, county councils and even the Fine Arts Commission.

In the construction of open framework gantries, trestles and similar units, the following considerations are important:—

(*a*) There should be as few structural members as possible.

(*b*) Horizontal surfaces, ledges, pockets at the intersection of diagonal members, and any similar device likely to collect dirt, coal and coke dust, or other deleterious materials should be avoided.

(*c*) Structural members should be fairly robust with adequate cover of concrete to the reinforcement.

(*d*) Structures that are partly buried in coal or coke should preferably be in reinforced concrete. Existing steel structures should be partly encased in concrete.

(*e*) No members other than the legs of the structure should be liable to become buried in coal or coke. This is particularly important in case of fires.

(*f*) Where mechanical plant is likely to operate around the base of any structure, due protection should be provided to the members in the form of metal column guards, blue brick facings, or generous chamfers, and curved arrises.

(*g*) Owing to the increased flexibility with height, special expansion and contraction joints may be omitted from gantries when supported on very tall trestles or towers.

(*h*) With very tall trestles, longitudinal stability may for economic reasons have to be provided by the superstructure. In these cases, expansion joints should be eliminated.

(*i*) Very tall, or otherwise inaccessible, concrete structures should be given a protective surface treatment as soon as they have been constructed.

While reduction in weight and the possibility of extensive prefabrication are major assets so far as steelwork is concerned, many of these structures are now being built in concrete on account of the anticipated reduction in the general maintenance costs, much of which is due to difficulties involved in access.

Restrictions

Problems related to the construction of gasholder tanks and foundations are very varied and have to take into consideration restrictions imposed by local authorities and by special geological conditions. The impact of large structures on the general public cannot be overlooked, and the fullest consideration

Taking the air outside the Festival Hall, left to right, are: Mr. A. G. Higgins, Institution of Gas Engineers; Mr. R. F. Hayman, Gas Council; Mr. W. V. Marshall, Bantry; Mr. R. L. Greaves, St. Helens; Mr. J. T. Haynes, Bournemouth; Mr. F. H. Bate, Chairman of the Midland Section; Mr. C. C. Wood, Sheffield and Mr. F. L. Atkin, W.M.G.B.

should be given to this aspect of the problem. Where site conditions permit, a tank below ground is usually adopted in built-up areas, whereas in open or industrial areas a steel tank with a raft foundation at ground level would probably be chosen.

The ultimate form chosen is, however, very much dependent upon the geological conditions of the site. Early brick structures relied for their stability partially on the resistance of the ground in which they were built, and for their water-tightness on the layer of puddle clay placed around the perimeter of the tank and on the tank bottom.

With the introduction of reinforced concrete, it became possible to carry more of the hydrostatic pressure on the structure and to rely less on relief provided by the surrounding ground both so far as stability and watertightness are concerned. It is not implied, however, that some relief cannot be taken when preparing the designs for a reinforced concrete tank; in fact, where no backfilling is involved, or where sheet piling is used, some considerable resistance would most certainly be available. These factors must, therefore, affect the choice of method of design.

Sketches are given in the paper, illustrating several variations in tank and foundation construction applicable to different site conditions.

COMM. No. 522 :

DISCUSSION

Mr. J. A. Hepworth (North Thames Gas Board): 'It will be recognised immediately that this is a paper which reminds all of us concerned with operations on works that while we may be primarily concerned with the physical operation of gas production in its many phases and in the creation of new and improved gas-making processes and techniques, the initial design and arrangement of new plant and structures is of vital importance for it affects the convenience and efficiency of operation and the number of men required on works for maintenance purposes long after the plant goes to work.

'Looking back on plants and structures that we have installed in the past, I am sure many of us would acknowledge that on occasions we wish we had incorporated some different design or arrangements or used some other form of material. The author is indeed justified in appealing for a closer examination of the circumstances of operation and the design features that should be incorporated in any new plants and structures.

'I am sure we have to consider much more seriously the justification for enclosing many items of plant and ancillary equipment within permanent building structures with their very high installation costs. Later this week there will be an opportunity to see the new oil gasification and gas reforming plants at Romford where the only permanent building is the operating control and machinery room. I have no doubt that in these days of greater facilities for centralised control arrangements there will be other opportunities to demonstrate the adequacy of the small control room building for the operation of plant installed in the open. There are, we know, many installations of modern boiler plants up and down the country with only minimum weather protection for the plant.

Left to right: Mr. R. Miller, W. J. Jenkins & Co., Ltd.; Mr. T. R. Cameron, Coleraine; and Mr. W. Iordan, S.E.G.B.

'In these days when the types of plant required for gas production can change quite rapidly the permanency of buildings is a matter which should be assessed very carefully to determine the most suitable type of structure that is necessary. Obviously, building structures should be designed to suit the plant they accommodate and for the expected life of the plant, and with modern materials available we have the facility to meet these requirements economically and at the same time produce buildings of pleasing appearance. As a corollary, we should be prepared to discard old plant buildings and not use them for purposes for which they are not essentially suitable, and for which they were not designed.

'In these days of high material and labour costs it is of prime importance that the maintenance requirements of buildings, roofs and other structures such as conveyors, service gantries, supporting trestles, etc., should be reduced to a minimum, and today designs and materials are available which give us a better opportunity than ever before to achieve this object.

'Apart from mechanical repairs the cost of protective painting can be extremely expensive indeed, and it is not unusual to find a typical works requiring some £400 per annum per million of installed capacity, exclusive of gasholders, to cover this expense. Faulty design is a sure source of high maintenance costs. The excessive use of small steel sections, the all to common back-to-back angles and channels and the use of lattice girder construction and steel window frames are but a few examples leading to heavy maintenance demands.

'For gas main and service gantries and for supporting trestles, concrete construction of proper design is much to be preferred to steel, and the modern prefabricated pre-stressed sections provide the answer in many cases. Where steel for one reason or another is preferred the welded tubular construction provides a satisfactory arrangement with reasonably low maintenance requirements. Steel window frames have proved completely unsuitable for works, and the use of concrete frames with glass bricks or lens glass have proved to be the most suitable for industrial buildings.

Corrosion

'We have still much to learn about the most suitable materials for roofs, particularly for retort houses and other structures subject to specially difficult atmospheric conditions. Experience with aluminium alloy sheeting has been variable with unexpected corrosion failures occurring from time to time. We had one case where the sides and roof sheeting of a coke conveyor gantry had to be renewed after only a few years life, but it would be wrong to generalise on this experience for we have learned that the composition of the aluminium alloy is important and, as the author points out, with proper selection of alloy and

careful fixing arrangements aluminium sheeting can be used successfully.

'From a recent brief study of plastics, including reinforced plastics, polyester and epoxide resins, it was apparent that these materials, too, are likely to have many applications on works although at present their very high cost will restrict their use. The protective coating of steel by polyester or epoxide resins—highly resistant to many corrosive conditions and atmospheres—may well ultimately be an answer to some of our corrosion problems and high maintenance costs on steel structures and might enable lighter and cheaper structures to be used.

'The author encourages us to be progressive in the adoption of new designs and new materials, but on p. 6* of the paper he says "Cost is one of the major considerations in any new project and very few reasons are accepted in justification of anything but the lowest tenders for the various works involved." This is apparently a real cry from the heart, and I think the lesson we learn from the paper is that adequate consideration and study should be given in the first place to all aspects of design requirements to enable us to formulate a precise specification of what we want. There need then be no doubt or difficulty in the acceptance of the lowest tender in the sure knowledge that we would get the most suitable structure for the job.'

Timber

Mr. D. H. New commented on what he considered to be a few salient points in the paper. The fifth paragraph on p. 45 might well be heeded by all designers. There could be no better medium of education than an intensive study of work executed under conditions of use. He would underline the first two lines of the last paragraph where the author said 'For want of a little extra time and individual thinking, many structures follow the traditional pattern without reason.'

The author had drawn attention on p. 36 to the advances that had been made in laminated timber, the use of which might well give the best structural solution in certain conditions in corrosive atmospheres. 'Of late we have tended to neglect the use of timber, but recent developments in lamination and glueing are arousing further interest.'

Mr. New went on: 'On p. 39 of the paper the author indicates that there is a fruitful field for research directed to the use of rubber in the gas industry. In this respect it is interesting to recall that Professor Vardepette of Ghent, in a recent lecture to the Reinforced Concrete Association, drew attention to the fact that neoprene had been used under the bearings of the recently constructed road viaduct in Brussels, to replace sliding joints, indicating that research into rubber and substances with similar properties has indeed very wide possibilities over the whole constructional field.

* Page numbers are given so that original texts may be referred to.

Mr. H. S. Cheetham, Woodall-Duckham Construction Co., Ltd. (left); and Mr. K. B. Meggitt, Bedford.

'The suggestion made on p. 76 that refractory work could be pre-stressed, with cables carried through gas-cooled ducts, has many attractions but is fraught with grave dangers since any failure in the cooling system would lead to rapid relaxation in the steel, followed by loss of the entire pre-stress.

'On p. 48 of the paper reference is made to a coking plant in Germany which is alleged to be the highest structure known of its type. This statement, followed by the magnificent structural conceptions which the author saw last week in Berlin, will no doubt have convinced him that the industrial challenge of West Germany is going to be very considerable which, if we are to answer it, leaves no great scope for any reduction in working hours in this country.

'On p. 37 of the paper there is a reference to the new jetty at Beckton and the practical tests that were carried out to obtain pull-out values for the hollow prestressed concrete piles. This work and the progressive design features used throughout the jetty are, however, only a natural outcome of the advanced thinking done by the author and his able chief, your President, Dr. Burns, since they arranged for the driving of the first prestressed pile in this country early in 1949, and followed this by using the first highly pre-stressed fender piles at Brentford.

Mishaps

'It is quite obvious from a study of the paper that many more structural ideas are being given consideration, and I feel confident that the gas industry can expect more interesting developments from this direction.'

Mr. L. J. Clark (North Thames Gas Board: 'I have come forward to speak on this paper for two reasons, firstly, because the author has referred to materials for use at high temperatures, and, of course, we have done work in that field, and, secondly, because in some recent Press reviews references have been made in connection with liquid methane to the mishaps in America with the plant at Cleveland and some people may have thought that there is risk involved here. This question is very largely one of selecting the right materials and knowing what the behaviour of those materials will be at low temperatures. For the construction of the tank at Cleveland a 3½% nickel steel was used which was known to be fairly brittle at low temperatures and that may have been one of the main contributory factors to the failure. There were design aspects to be taken into account as well—the siting of the plant was extremely bad.

'At the moment, as the author has mentioned, we are using aluminium as a material for low temperatures. Considerable work has been done to establish the properties of this material. We know that its tensile strength, ductility, and so on are good. We are quite satisfied that the material is sound. That is not the end of the story, however, because aluminium is an expensive material and we must consider others as well. There are other materials and there are problems relating to structural supports in which there are laminated materials and materials of mechanical strength which can be used. They, too, offer considerable possibilities. Even rubber, in the expanded form, as an insulator looks as though it is a very satisfactory material and it will probably be used for insulation.

Conclusion

'Then there is the insulation in the form of polyester materials and they bring in all kinds of new problems. The behaviour of such materials in restricted spaces must be studied because they may change dimensionally as a result of change of temperature and we have found that there are very large build-ups of pressure due to conduction. All these things have led to further research and, we hope, to solutions.

'Finally I should just like to refer to the author's concrete trumpet. He really might have mentioned that in the United States there is quite a spectacular tank to contain 2,000 tons of liquid oxygen which is manufactured entirely of concrete. It is a post-stressed structure operating at a temperature of minus 300°F. How it is brought into action and taken out of action requires special techniques but it is a possibility. It has not been a complete success but it did achieve a considerable reduction in price. In these low temperature projects we must, I think, look forward to using cheaper materials so far as possible and it may be that the concrete structure will be fully successful.'

The **President:** 'I think we have to recognise that whatever plants and processes we may have to have, they must be efficiently designed. We have got to make use of the most suitable raw materials and do the best we can with the money and investments that are available to us.

'Mr. Clark gave us a brief impression of some of the entirely new material problems which are arising in some of our new techniques and I think it is of great value to the Institution to have a work of this type on its records.'

THE PRESIDENT'S LUNCHEON

'The gas industry—an indispensable part of the industrial fabric of Britain'

Sir Harold Hartley describes the fuel pattern of the future

DR. BURNS apart, this must be described as Sir Harold Hartley's meeting. Not only did he receive the Birmingham Medal on the morning of May 13, but he contributed the speech of the day at the President's Luncheon which followed. Replying to the toast of 'The Guests,' he described himself as 'a hardy annual at this festive board,' and spoke of the various ways in which gas had influenced his life; he then outlined what he thought would be the industry's opportunities and responsibilities in the years ahead.

'I have never wavered in my view that the gas industry is an indispensable part of the industrial fabric of Britain,' he said. 'That fabric is changing quickly. . . . I have always held that electricity and gas are complementary to one another.' Referring to the Presidential Address, which he described as 'a masterly survey of the new look of the gas industry,' Sir Harold said: 'I am sure we all admire the realistic way in which you analysed its problems and your imaginative sketch of the developments by which they could be solved. You talked of a high-pressure gas grid, or pithead gasification of low-rank coal to carry the base load and the gasification of oil at refineries to carry the peaks. The emphasis all the way in your talk was on gasification, rather than carbonisation. That seemed to me to be the new look.'

Great Opportunity

It was most unlikely that our great coal reserves would ever be matched by indigenous oil and natural gas, he said. That was the great opportunity that the gas industry had before it, for gas was an ideal fuel; it was a clean, flexible source of high-grade heat. 'I am thinking of its future not merely in terms of industrial and domestic gas, but of synthesis gas, of gas for the eventual synthesis of oil and hydrogen, which, like oxygen, is in increasing demand.' The President had spoken of the increasing amount of coke oven gas which would be available. It was quite on the cards that a good deal of that iron ore would be reduced in fluidised beds by hydrogen if the gas industry could make it cheaply enough. Price was one of the great factors in their future.

Sir Harold continued: 'I have recently had the most encouraging experience of visiting the Gas Council's experimental work at Solihull and seeing the great progress that is being made there under Dr. Dent's skilful leadership. On the whole, I think I put my money on the slagging pressure gasifier. I know that it has great technological problems still to solve and everyone does not agree with me, but we shall see.'

The President had also spoken in his address of the Gas Council, and particularly the North Thames Gas Board, being on the threshhold of adventures in bringing liquid methane into this country. 'In the Middle East I have seen natural gas going to waste in those great pillars of fire and smoke, and I wish you every luck in your courageous experiment. But I see the gas industry on the threshhold of many other adventures. Not all of them will succeed, but on them, I think, a great deal of your future depends.'

Power for Good

As we have said, Sir Harold was replying to the toast of 'The Guests.' This was proposed by the President, who spoke of the power for good which a professional institution may have in an industry.

'When one has the opportunity, as I have had, of travelling up and down the country in the past year to meet the various sections of the Institution and to appreciate the great goodwill and the great good fellowship which exists between the members of the Institution, one cannot help wondering where that comes from. The great feature of the professional body is that all work which is done for the professional body or institution is voluntary work. That is very important. Furthermore, the professional body creates a nucleus for social meetings such as we have today. It is one of the great features of this meeting that friends can associate with friends.'

Sir George Thomson, D.SC., F.R.S., Master of Corpus Christi College, Cambridge, proposed the toast 'The Institution of Gas Engineers.' He said it was clear that the gas industry was on its tiptoes looking forward to all possible changes, and referred to total gasification of various forms of fuel and to the import of liquid methane, 'which, incidentally, raises interesting questions for a physicist who is used to liquid air and liquid hydrogen, but who is not used to handling them in 5,000-ton units.'

There was no doubt that it was a time of rapid change. Nuclear power from uranium was already a very lusty infant and was growing at a great rate. Then there was the thermonuclear business, which was still only a possibility—or, rather, only a probability. Both of these were, or would be, mainly producers of electricity. They affected the gas industry mainly, but not entirely, in so far as the electricity might be a competitor.

Speaking of how these things might affect the future, Sir George dealt first with fission—nuclear energy that was derived from uranium and perhaps, someday, would be derived from thorium. There was no doubt that the first cost of the plant would always be higher than in the case of the corresponding coal plant, because virtually you had the reactor added to a normal coal plant; at any rate, a reactor was more expensive. On the other hand, the fuel cost was much less, even now. It was also one of those industries that depended on an important by-product. As much as gas depended upon coke, so nuclear energy from uranium depended to some extent on the production of plutonium and the value assigned to this plutonium. This kind of accountancy was difficult and was best left to accountants.

'I am convinced that nuclear energy will be fully competitive with coal; and if the price of coal goes up more than the general inflation of everything else, it will be considerably cheaper than coal. It is much harder to say what the time scale will be. I do not think this will in general affect you much for ten years, but I should think that in 20 years' time it will be very important.

Cheaper Electricity

There would be somewhat cheaper electricity than would otherwise be the case and this was one of the things which would tend to hold down the price of coal. 'At any rate, our friends in the Coal Board will not be able to hold the country to ransome; I hope that this may benefit the gas industry.'

Turning to energy from fusion—that is, from hydrogen—Sir George said that while this was a possibility, it was not a possibility for the immediate future. 'I think we shall be fairly lucky if electricity from fusion is being poured from the grid in 20 years' time, although I think it will probably be done about then. Whether that will be cheaper or more expensive, I do not have the least idea.

'I do not mind sticking my neck out as far as most people, but to predict the economics of a machine which is not yet working is not courage: it is just plain silliness. It is difficult to say how these things will affect you, but one thing of which I am quite certain is that an industry as far-seeing and energetic as yours will adapt itself to changing circumstances and that there will certainly be a place in the world to come both for the nucleus and for the gas molecule.'

Air Chief Marshal Sir Arthur Sanders, G.C.B., K.B.E., Member, North Thames Gas Board, proposed the toast 'The President.'

95th A.G.M. — a 'GAS JOURNAL' Abstract

COMM. No. 528 AND DISCUSSION

BY-PRODUCTS

in the economy of gas manufacture

by

L. W. BLUNDELL

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CONTROLLER OF BY-PRODUCTS, NORTH THAMES GAS BOARD

FOR 70 years prior to nationalisation the Gas Light and Coke Company had processed crude by-products from its various gasworks at its own by-products plant at Beckton, and had taken over a smaller by-products plant at Southall on amalgamation with the Brentford Gas Company in 1926. Under the North Thames Gas Board, this policy has continued, and, at the present time, the quantities treated annually are as follows:

	Beckton	Southall
Crude tar (tons)	230,000	30,000
Crude benzole (gal.)	6·5 mill.	3·5 mill.
Crude ammoniacal liquor (gal.)	132 mill.	nil
Spent oxide (tons)	20,000	nil

The treatment of by-products at Beckton commenced in 1879, sales of tar products being negotiated from an office in the City of London. The story of the Beckton products works in subsequent years closely reflects the development of the by-products industry as a whole.

The expansion of by-product recovery at last outstripped the vision of the early designers, and, after World War II the Beckton products works entered upon its third phase, when reconstruction had become necessary. Transfer to another site was considered by the Directors of the Company, but, having in mind the development of Beckton as a whole, it was decided to reconstruct on the present site, adjoining the largest gasworks and source of crude materials, and where the greatest increases in gas-making capacity were anticipated.

Reconstruction

The reconstruction of the products works has been one of the main tasks of the author, who succeeded W. G. Adam as Superintendent in 1946, and later became Controller of By-products in 1950, with responsibility for both works and sales organisations.

In the management of the products works, and in the work of its reconstruction, the author has been fortunate to have as colleagues D. G. Murdoch and C. C. Smith, both chemical engineers of great experience and high standing in the by-products industry. The contribution that they and their respective staffs have made to the position of by-products in the operations of the Gas Light and Coke Company, and subsequently in the North Thames Gas Board, merits the author's fullest and most generous acknowledgment.

At the present time, Beckton gasworks supplies 40% of the tar and liquor received at products works, Beckton, and 66% of the crude benzole.

In recent years, there has been a considerable increase in the number of road vehicles serving the works, both in the reception of raw materials and stores and in making bulk deliveries of finished products. Crude tar and gas liquor arriving at Beckton by barge are pumped through 18- and 12-in. mains, about 1¼ miles long, into the works storage system; the same mains carry the tar and liquor from Beckton gasworks. An unusual feature is the 6-in. liquor main connecting the products works with Poplar, Bow Common, Stratford and Bromley gasworks; it is about 6 miles in length, and runs beneath the streets of East Ham, West Ham and Poplar. This means that two-thirds of the liquor supplies are safeguarded and virtually under works control.

The Board treats nearly 90% of its own production of crude tar, the remainder being sold to distillers under co-operative schemes existing since before vesting date. There is also a standing agreement with the Ford Motor Company to take its crude coke oven tar from Dagenham, and this forms a useful additional source of high-aromatic products.

The crude tars distilled are derived from horizontal retorts, coke ovens, vertical retorts and intermittent vertical chambers. While the crude tar at products works, Beckton, is substantially high-aromatic in character, a range of low-aromatic tars, possessing valuable properties, is also available. About 75% of the tar distilled at Southall is used to make refined tar for roads, the works acting as a delivery centre for the greater part of the Board's home road tar business.

The availability within the Board's area of an extensive range of crude tars permits the use, by selection or blending, of the best raw material for the production of pitches and refined tars for a wide variety of purposes. The advantages of this flexibility are shown by the successful use of North Thames tar for the surface dressing of roads, for the manufacture of tarmacadam, and of North Thames pitch for briquetting coal.

Modification

One significant property of crude tars is the degree to which they undergo modification during heat treatment, as, for example, during distillation. It has been found that during distillation (*i.e.* the removal of volatile oils) the toluene-insoluble constituents (carbon filler and resins) increase to a greater extent than can be accounted for by the simple concentration effect. This behaviour is very marked in certain crude tars, and slight in others.

This variation in thermal stability has been used to meet various specification

requirements, and the Board has been assisted in this by the fact that it has tar distillation units of varying severity of heat treatment. In consequence, it is possible to produce pitch to meet special requirements, in the manufacture of electrodes for the aluminium industry, in the manufacture of graphite moderators in atomic energy reactors, and for the production of pitch/fibre pipes.

Most large gasworks have benzole-recovery plant available, and during wartime these have always been encouraged to operate at maximum extraction. In the coke oven industry, benzole recovery is almost universal; in the gas industry, however, considerable discussion has always taken place on the economics of benzole recovery during peace-time. Normally, the question to be answered is whether the benzole hydrocarbons yield a greater financial return, when extracted and refined, or when sold as gas to consumers.

No Place

Benzole recovery has certain technical advantages, however, that result in financial savings, which, accruing remote from the plant, find no place in its cost accounts. These include reduction of organic sulphur, removal of naphthalene, and removal of unsaturated bodies that by polymerisation, form sticky deposits. Thus, at marginal levels one may have to decide whether the cost of benzole recovery considered as a gas purification cost is more advantageous than that of alternative processes, even if such processes can, in fact, be operated successfully.

By far the most troublesome of the chemical by-products produced in the carbonisation of coal is crude ammoniacal liquor. The disposal of this offensive product is a statutory obligation of all area gas boards, and a considerable amount of work has been carried out on its treatment and disposal. Almost the whole of the ammoniacal liquor produced in the North Thames Area is taken for centralised treatment to the products works, Beckton; seven of the 18 manufacturing stations concentrate their liquor before despatch.

The main purpose in treating spent oxide is to render the works self-supporting in its requirements of sulphuric acid for the manufacture of sulphate of ammonia. The provision of plant adequate to meet winter demands for acid results in the production of a useful marginal surplus for sale in the open market. Beckton's acid plant consumes about 50% of the sulphur extracted in the Board's oxide purification processes, the remainder of the spent oxide being sold at home and abroad.

Another important source of sulphur is provided by the exit gases from the sulphate of ammonia saturators; these gases contain hydrogen sulphide, which is converted to concentrated oil of vitriol by the contact process. The tonnage of acid so produced is more than sufficient to meet the Board's needs for the acid-refining of benzole and tar products.

The crude by-products so far mentioned have been only those derived essentially from coal. In addition, the Board produces a substantial quantity of carburetted water gas tar, which, although varying considerably, is now of the order of 4 to 5 mill. gal. per annum. This tar is always segregated from crude coal tar, and at present finds its main use as liquid fuel for steam raising at a number of the Board's stations, some quantities being disposed of by direct sale. Recently, however, carburetted water gas tar has assumed a much greater significance as a source of industrial pitches and other valuable products.

Recently, the Board has begun to produce tars in significant amounts as by-products of catalytic oil-gasification processes. In the planning and design of these plants, it was intended that the tars should be employed as fuel in the operation of the processes, or for general steam raising. On careful examination, however, these tars have shown certain interesting characteristics and certainly merit further study. Difficulties have been encountered in the separation and handling of these tars because of their highly cracked nature, but, clearly, such difficulties will in due course be overcome and thus provide the tar distiller with interesting new sources of crude tars which will partly compensate for any reduction in the output of coal tar from traditional coal gas plant.

Mr. Blundell proceeds to set out the general scheme of operations at products works and then to discuss briefly the individual plants and processes. Two figures show diagrammatically the main principles of tar, benzole and ammonia treatments.

For the treatment of tar the Beckton plant consists of two continuous pipe-still fractionating units and a pot-still section. Phenols, naphthalene and pyridine bases are recovered from the tar.

The Beckton benzole recovery plant employs ' two Barbet continuous units for primary separation, yielding forerunnings containing about 12% of CS_2, a benzole fraction that is inhibited and used for motor benzole, a toluole fraction and a residue.' This section concludes: ' Cheaper and more efficient methods for the refining of gasworks benzoles are urgently required and investigations are proceeding along two distinct lines: First, the process of hydro-refining (catalytic hydrogenation under pressure) is being examined as an alternative to the present chemical treatment for the removal of sulphur and unsaturateds, and, secondly, various methods of effecting the separation of pure benzene from associated paraffin compounds are receiving careful study.'

Cost of Disposal

The main duty of the concentrated ammonia plant is to process the liquor economically, since only 3% of its constituents are capable of yielding saleable products; the process has to bear the cost of disposal to the sewers of an effluent 20% greater in volume than the original liquor. Dephenolation of the liquor is the most profitable section of this treatment. New materials of construction of plant in which corrosion is severe are briefly discussed.

Plants for the production of sulphuric acid at Beckton are designed to meet the requirements of sulphate of ammonia manufacture and the refining of coal tar products; 87% of the acid produced at products works is consumed in these processes. ' The ash residue from the burning of spent oxide . . . no longer presents a disposal problem. Approximately 18% is used for the manufacture of artificial purifying material for use in place of, or in conjunction with, bog ore, and the remainder is sold.'

On the marketing of products, home sales account for about 70% of the output of bulk tar products at Beckton, while in the export field briquetting pitch is sent to the Continent, electrode pitch to Australia and Canada, road tar to the Continent, New Zealand and the dollar area, and creosote to America and Scandinavia. An interesting point is the undertaking by products works of road surface dressing with its own mechanically driven road-spraying tank vehicles. Its road tar is now highly valued in highway practice and the Board maintains a large fleet of spraying tankers manned by skilled operators.

Importance

Phenols, naphthalene and pyridine bases have grown considerably in importance as essential raw materials of the chemical industry, in the fields of moulded plastics, synthetic resin-bonded materials, plasticisers, synthetic fibres, etc. No major disposal difficulties remain with chemical tar products.

The future of benzole also lies with the chemical industry, where there is a big demand, still unsaturated, for benzene for the manufacture of nylon, styrene plastics, detergents, phenol and dyestuffs.

Sulphate of ammonia finds its established outlet as an agricultural fertiliser; the balance of the ammonia produced is marketed as ammonia solution of exceptionally pure quality.

This portion of the paper concludes with a brief discussion of the newly developed works' services, steam and power generation with allied and ancillary plants.

The processes and operations described in previous sections result in the discharge of approximately 1 mill. gal. of industrial effluent daily (excluding the spent liquor from the ammonia recovery plant). Formerly, this effluent flowed into the Thames through a settling-bed and oil interceptor, but the passing of the River Boards Act, 1948, and the Rivers (Prevention of Pollution) Act, 1951, rendered it necessary to alter the method of disposal. By an arrangement made under the London County Council (General Powers) Act, 1953, the effluent is now pumped into the County Council's main sewer for treatment at the Northern outfall works, at a charge based upon its ' strength ' in respect of oxygen absorption, nitrogen content and suspended solids compared with ordinary sewage.

A semi-automatic mechanised effluent reception plant designed to guarantee sub-

stantial freedom of the effluent from solids and oil, has replaced the old settling-beds.

The new plant has been in operation since September, 1957, and, in spite of having to deal at times with decidedly oily or cloudy liquor, it has not failed to send forward a satisfactory effluent to the County Council sewer. The principal problem remains the satisfactory disposal of the sludge from the process. This material is of a buttery consistency when at rest, is markedly thixotropic and contains up to 95% of water, the solids being mainly chalk with entrapped oil globules. At present, it is discharged into lagoons from which the water evaporates, leaving a solid residue for disposal. The question of alternative methods of dewatering is engaging the attention of the works research section.

The need always exists for systematic research principally directed towards the following objectives, *viz.*, the assessment of changes in crude materials, the improvement of process techniques, the selection and production of materials to meet particular requirements, and the isolation of new chemical compounds for which a demand exists. The products works has for many years maintained its own research department working on these lines. Most producers and distillers co-operate in centralised research sponsored by trade organisations.

COMM. No. 528

DISCUSSION

Mr. W. K. Hutchison, Chairman, South Eastern Gas Board, opening the discussion, said, 'The presentation of a comprehensive survey of the processing and marketing of by-products of the gas industry presents a unique opportunity for gas engineers to learn about certain problems which vitally affect the economy of their own industry. A study of this paper reveals also how much Mr. Blundell has found in common with the problems facing the gas industry in overcoming dilapidation, obsolescence, and war damage. Just as in the gas industry after the war there was the overriding necessity of catching up with increasing demands, so in the by-products industry it was necessary to deal with increasing quantities of tar and ammonia liquor, but it was necessary also to reconstruct in such a way as to take advantage of new and expanding markets for materials demanded by the chemical industry.

'Traditionally most of the tar industry used to be in the hands of independent distillers who were living in a strongly competitive market where the highest bid for crude tar might determine its fate over a number of years. Thus these distillers and, following them, those gas undertakings distilling their own tar, for many years carried on their operations in conditions of the closest secrecy. Perhaps a little of that remains today, but the reason was, as Mr. Blundell has said, that in the early days tar distillation was an art rather than a science, with each process developed by trial and error from the test tube scale. It must be to the certain knowledge of many of us that quite minor improvements, the principles of which were perhaps not properly understood, could make it possible to produce a material which might have just that little extra quality which would determine its sale at enhanced prices. We were not going to give that secret away to a competitor.

New Outlook

'In the last thirty years there has been brought to bear on the tar industry, as indeed on the whole chemical and petroleum industry, a new outlook based on the conception of the unit process and an understanding of the underlying principles which determine the design and operation of chemical plants. While the author, for reasons which are quite obvious, has not been able to present us with working details of the process operated at Beckton, it is quite apparent that the approach to the problems of tar distillation today is that of fundamental chemical engineering rather than the building up of plant on the basis of previous know-how, and the result is beautifully illustrated in the new continuous carbolic acid distillation plant, a model of which has so rightly been judged worthy of exhibition at the Science Museum.

'On the marketing side the past history of tar distillation has been one of rapid and incalculable fluctuations, with periods of over-supply of the main products leading to ruinously low prices, alternating with periods of scarcity and inflated values. As we have heard today, and most of us must realise only too well, the industry is debarred from taking one effective form of control, that of reducing output, owing to its contractual obligations to receive and pay for raw materials in such quantities as might be delivered to it at any time. This leads to the thought that the industry may have brought some of its difficulties on itself by operating under conditions of competition which hurt only the producer and benefited only the purchaser, and perhaps most of all the dealer, who can buy and sell at the right time. This is particularly true in the field of bulk tar products—pitch, tar and creosote—where stability depends on satisfactory exports. Efforts have been made over a long period to try to correct this by schemes of bulk purchase and marketing for the common account by quotas and by dispersal payments, but even before the passing of recent legislation made such operations subject to public scrutiny, it appeared impossible to maintain any such arrangement for long enough to prove its value. The fundamental difficulty is that in an industry in which the quality of raw material is fixed and beyond its control, satisfactory marketing requires that surplus products must be disposed of from time to time at quite unremunerative prices, for example as fuel, in order to maintain the balance, and no single producer is ever going to be the first to sell in the low field. The problem remains unsolved, but I trust that others will come along who may achieve more success than we have had in the past. I hope it will not be forgotten that the whole United Kingdom production of some 2 mill. tons of tar makes a very small ripple in a pool of 50 mill. tons of oil which is being imported and processed each year in this country.

'As I have said, the author has illustrated his theme by describing the reconstruction of the Beckton works, and here there is much of interest to the gas engineer. I had hoped that the paper would be illustrated by a general lay-out diagram, for I well know that in 1945 a major problem at Beckton was to evolve a satisfactory and efficient lay-out on a site where so much improvisation had taken place over the 60 years of its existence. The first impression of Beckton after the war was one of complete inaccessibility. The works had grown up round a railway system and the new conditions in which road transport was to play such a large part, not only in the movement of goods, but also in servicing and maintenance, made it necessary to replan the whole works round a really satisfactory road system. Another point which I think a works plan would have shown is the value of the concept of checkerboard planning by which each main section of the operation is confined within its designated area. In modern petroleum refineries this practice is universal. It is a simple matter on a new site and an exceedingly involved one on a site such as Beckton.

'The workshops and maintenance staff appear to be on a very large scale. The author anticipates criticism of this by referring to the need at all times to be ready to relieve the gasworks of their tar and other by-products. On this point, as in the matter of works lay-out, there are problems common to the gas industry and at Beckton products works. Traditionally in the South of England we appear to have favoured maintenance by our own staffs up to construction of quite large items of plant on the grounds that every emergency must be cared for. The danger of this outlook is that large staffs are on hand who may quite soon be diverted into relatively non-productive work and may be producing items of equipment which would be better bought out from specialists. Whenever I see a foundry at a gasworks I ask them whether they are casting any lamp standards! The problem is one which lends itself well to method study and planned maintenance techniques, but here again the problems are much more difficult in an older works with established customs and practices. The co-ordination of power and steam at a works of this kind is possible on a far larger and more effective scale than at a gasworks, although similar studies are well worth while wherever heat and power are required in a process.'

Colonel F. M. Potter: 'I do not propose to get involved in a discussion of the details of plant and processes described by the author but will confine my remarks to those which I hope will

be of some interest to the gas engineer, and I find I shall have to discard much of my notes, for although written four hundred miles away from the author I think it is quite natural that I have tended to some extent to cover the same ground, but where I do repeat what he has said I hope it will perhaps help him to drive the point home. At the foot of p. 6 of the paper we read that "the quality of the raw materials received is of the greatest importance to the distiller, and, equally, should be the constant concern of the producer, in order that both may derive the maximum revenue from the products." This holds true whether the liquid by-products are evaluated by the works owned by the board as at Beckton or under the co-operative tar schemes, for it is the producer who receives the major portion of the increased revenue from improvements whether in cost of production, enhanced quality fetching better sales revenue, or increased yields of the more valuable products.

Reduces Corrosion

'Reduction of liquor and fine inorganic matter in the crude tar reduces corrosion in the pipe still, lowers fuel consumption and lengthens the on-stream period. Some tars tend to contain a small percentage of very fine ash apparently derived from the coal ash and the retort brickwork. This fine ash is coated with an aqueous film and refuses to settle even in prolonged storage, but settles out in the dehydration plant when, following the evaporation of the water, the ash is wetted by the tar. Assessing the ash in this form at 0.005%, it is equivalent to 22 lb. per day on a 200 ton per day plant which if deposited in a 4 in. coil will materially shorten the on-stream period. It would be of interest to hear from the author whether there is any evidence that the Russell screen, in addition to facilitating liquor removal, removes with the other solids this fine ash.

Close Specifications

'Refined tar products are sold to relatively close specifications, and pollution of the raw material, unknown to the distiller, with an abnormal tar or oil may give rise to an off colour or an off specification product, the cause being difficult to trace at the receiving end. The past changes in gasworks practice—from horizontal to continuous vertical and in two areas to the adoption of the coke oven—gave rise to changes in the nature of the crude tar. But these changes were those of degree and came into practice only steadily, thus enabling the tar distiller to amend his refining processes and produce products which, although different in certain specification details such as specific gravity, were proven in practice to fulfil the requirements of the user. Service tests showed that the new products were not less efficient than the old. In this respect Beckton was favourably placed by its ability to segregate types of tar and blend.

Left to right: Mr. H. D. Robinson, Lancaster; Mr. J. Corrigan, Leicester; Mr. H. Blythe, Colwyn Bay.

'A new position has now arisen and is developing in which greater changes are being made in gas production methods than one might say has occurred in its previous history. Some of the new tars are basically different from coal tar as we have known it, and it is to be hoped that the gas engineer will keep the tar distiller fully in touch with the new developments, and as soon as the operation details have reached some degree of finality will submit samples to the Coal Tar Research Association and to works laboratories for investigation. It may well be that some of these tars at present classified as difficult will yield new and valuable products, but radical changes in refining methods may be required. The easy and possibly uneconomic method of employing these new tars as a low priced fuel oil should be the last resort. The recovery and refining of benzole provides a good example of co-operation and consultation between the gas side and the by-products' side. The author has stated that the benzole extraction process in addition to its main objective, benzole recovery, improves the gas, particularly from the distribution engineer's point of view. The adoption of the active carbon process at Beckton gas works improved the efficiency of benzole recovery but also led to the removal of about 70% of the organic sulphur in the gas with the consequent production of a crude benzole very high in carbon disulphide for the refining of which the old batch stills and columns were inadequate. This was followed by the greatly improved efficiency of the oil extraction process devised by the Fulham research staff. The installation at Beckton of the Barbet continuous stills, hitherto used in this country only for alcohol production, led to the regular and consistent reduction of the CS_2 in the once distilled product to below 0.02% and the further adoption of the polysulphide process enabled the efficiency of recovery of saleable hydrocarbons to be usefully improved and the carbon disulphide to be sold as a marketable product at the expense of a corrosion problem apparently not yet fully solved.

'An integrated works like Beckton products works can and does make a major contribution to the effluent problems of the associated gasworks. As shown by the author, the centralisation of liquor has enabled the development of the dephenolation process, extracting 90% of the phenols in the liquor and halving the oxygen absorption figure of the effluent, this stage being revenue producing and reducing the final cost of effluent disposal.

Alert and Flexible

'The many world and home factors which affect sales revenue require a very alert and flexible production programme and sales staff, as the author has truly said. While the basic revenue is still obtained from the traditional century old markets of pitch and creosote for timber preservation, the additional much sought after revenue is obtained from organic chemicals for the plastics, paint, crop protection and pest control industries, and other modern developments. A net revenue of, in round figures, £14 mill. per annum from tar products is surely an important contribution to the industry's financial surplus on the year's working. From the national point of view in the normal year, as far as I have been able to trace, the direct exports run up to about £10 mill.—not quite as useful, perhaps, as those of the distiller of the more delectable product, but in addition one has to take into account the very large and unassessable income to this country from exports of manufactured products of which a tar product is a primary raw material.'

Mr. F. M. Birks: 'Before vesting, the products works were under the jurisdiction of Mr. W. K. Hutchison, who was the Managing Director of the Gas Light & Coke Co., responsible for that side of the business. That was nearly 12 years ago. He laid down the policy for this immense reconstruction with great boldness and to such good purpose that during the necessarily long time the work took to be carried out, due as the author states to the difficulties in keeping full output of the existing plant, hardly any alteration to the general plan was necessary. At that time the reconstruction of the gasworks had completely swamped the general engineering side of the company, and it was for that reason

that Mr. Hutchison introduced consulting engineers, Messrs. Bryan Colquhoun & Partners, and they helped very greatly to produce this very advanced design. For certain sections of the works they designed some very heavy aluminium lattice structures for carrying cables and pipelines, and so on, and when they did this they took advantage of tests which had been carried out over a number of years by Aluminium Research, in certain parts of the products works where I could only describe the atmosphere as being unspeakable. It varied unaccountably from extreme alkalinity to extreme acidity and by corrosion, got rid of almost any metal which was put about, but they found out that certain of the aluminium alloys could stand this very dreadful atmosphere, and it was for that reason that this very heavy aluminium structure was put up. I think it would be safe to say that apart from corrugated aluminium sheeting, there is more aluminium structure at the products works at Beckton than in the whole of the rest of the gas industry.

Accountant's Delight

'The power arrangements are of great interest and of very high efficiency and the future allocation of costs between the different sections of the works using varying pressures of steam and the division between the products works and the gasworks may, in the course of time, become an accountant's delight. The general layout of the works is very attractive, the wide roads and pleasant buildings are most impressive, and the ease of handling materials from one section to another is marked, while the central workshops must, as time goes on, contribute very considerable economies in the cost of maintenance. The technical staff of the works has been greatly occupied for years on the new chemical plants which have been built, while from time to time difficult and most interesting problems have arisen which have only been solved by the experience and skill of the engineers dealing with them.'

A contribution from **Mr. W. Green,** President of the Coke Oven Managers' Association, was read by the Secretary. Mr. Green said, 'I should like to compliment the author on the excellent presentation of his subject. I am particularly interested in his remarks regarding the corrosion of condensers in the benzole plant and would enquire if any similar corrosion has been observed on the still shell and if so, to what extent. With regard to the use of ammonia in the treatment of distillate, would the author state if the *p*H value of this product was determined, and if so, at what value was it maintained? I suggest that the admission of ammonia as gas into the still might be an alternative method to treat this corrosion difficulty, particularly so if corrosion is present in the still shell. Ammonia gas could be admitted at such a rate as to maintain the *p*H value as near seven as possible. Could the author state if any substantial deposit occurs in the vapour side of the condenser, and if so, is it possible to remove this deposit *in situ* or does its removal require mechanical handling? In view of the increased demand for pure products I agree with the author that the two types of crude benzole treated must be separated to produce the best results, in order to satisfy the technical and economic requirements.'

Mr. R. N. Bruce, Deputy Chairman, North Thames Gas Board: 'As most of what I had hoped to say has already been said I shall confine my remarks to emphasising certain points. First of all, Mr. Birks has referred to an "accountant's delight," and I know that the question of tar works accountancy is a very difficult one, but if we presented the revenue from our tar works at Beckton in various ways it might give some idea of its importance in the general economics of the gas industry as a whole. The sale of by-products represents something like £5 mill. per annum, or looking at it in another way, 19s. per ton of coal carbonised, or possibly if we look at it as net revenue we make something like £2 mill. per annum, or, taking into consideration depreciation charges on capital, about £1.5 mill., which is approximately 1d. per therm. That is quite a significant amount when we are trying to produce gas at the lowest possible price, and therefore I should like to come to a point arising from that, and this is said in no way in criticism. If the gas engineer can from time to time give a little more thought as to how he can inform his colleague the distiller of the materials which are coming to hand, and even more so when slight changes in carbonisation take place it will, I know, help the distiller very much indeed. We are obtaining quite high premium prices for some of our pitches and tars at the present time, which the distiller has to make to a very close specification, and if the crude product can come along to even a broad specification it will be most helpful. It will also help, I suggest, to pay for some of the things which we have to think about at the moment. If we are going to have our products to these close specifications we have to pay money for the segregation and storage of the groups.

Pure Benzole

'If I might try to look forward to the future for a moment there are one or two things I should like to say. There is no doubt in my mind that benzole is becoming more and more difficult to process to economic figures, and I am not quite sure in my own mind that the solution to this problem is the production of pure benzole. If we look at the amount of pure benzole which might be used in the chemical industry in the future I think if all our crude benzole went into that market it might very well saturate it. Again in the by-product market I suggest we have to remember that there is the European Common Market perhaps not very far round the corner, and it is not only our own production but the total production in Western Europe which may be rather a significant factor. So perhaps from the benzole side it does mean, as Mr. Clark and Mr. Spivey mentioned the other day, the possibility of purifying it and then putting it back in the gas. Another product which I am afraid is giving us headaches at the moment is the ammonia liquor. The prices for ammonium sulphate, I would say, would be going down, and the quantity which we can put on the land is limited by the situation of the production units in the industrial areas and the large transport costs to the agricultural areas, and although I would suggest that all of us would be wise to put as much as we can on the land it is only a small quantity out of the whole. In various papers mention has been made of the new processes for gas manufacture. This is probably a suggestion which can be shot down straight away, but it does occur to me that in the future we may be getting fairly large quantities of carbon dioxide under pressure. Is it beyond the wit of the technical people in the industry to combine that with the ammonia in the gas to produce what I think would be an excellent fertiliser of high nitrogen content, in other words, urea? I believe that may be the future solution to the problem of getting rid of our ammonia.

A group of visitors find something of interest at Romford.

Spent Oxide

'Lastly, there is the difficulty which has already been mentioned and which I think will be growing on us even more, and that is the question of getting rid of spent oxide. At the moment there is a very marginal price to be obtained for it, and with the large supplies of sulphur becoming available in the natural gas fields in the South of France this is again something to which we should turn our minds, to see if there is some other way of disposing of it.'

- George Kent, Ltd.
- Coryton Refinery
- Beckton
- Romford

Visits

- B.C.U.R.A.
- G.E.C. Ltd.
- Oxford
- Glover & Main

Electronic Instruments Seen in the Making

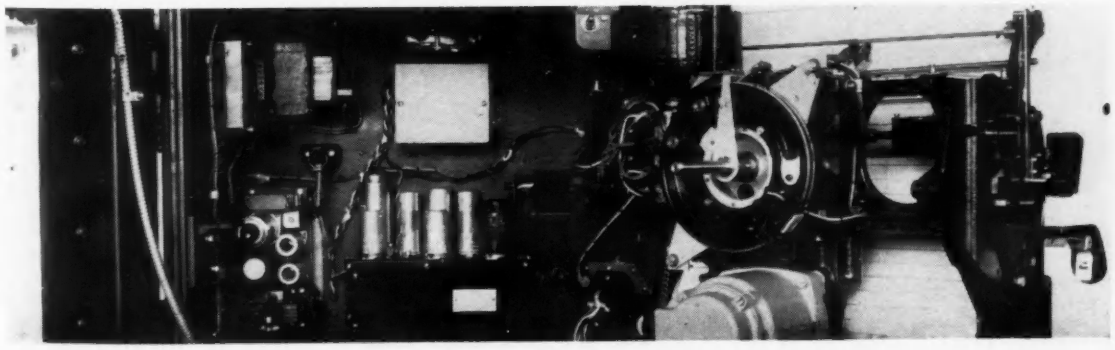
THE veil of mystery which shrouds electronic devices for most of us was lifted briefly for Members when they visited the works of George Kent, Ltd.

For here they were shown the assembly and calibration of Commander and Multelec instruments, as well as ring-balance gas-flow instruments. They also saw instruments of the potentiometric type for temperature, pH value, and oxygen-percentage measurement, etc.

The tour included a visit to the departments concerned with the fabrication, wiring, and assembly of instrument panels. Many of these are destined for overseas projects, and the one pictured above, which the visitors saw, is for the Boundary Dam thermal generating station, Saskatchewan, Canada. The complete panel is 35 ft. long. The picture below shows a close-up view of the Multelec instrument, the engineer is seen installing in a panel section.

The Company employs some 2,000 people and is devoted almost entirely to the design and manufacture of industrial instruments and meters.

Picture of Boundary Dam instrument panel by courtesy of Engineering Ltd.

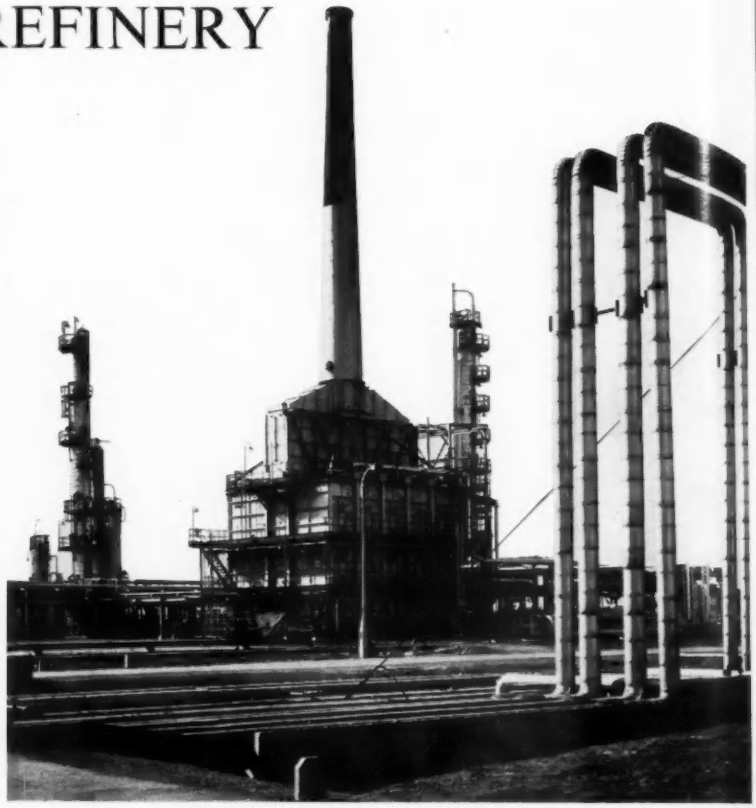


CORYTON REFINERY

WHEN Coryton refinery was built the volume of Middle East crude oil which was expected to be processed in the first year was 1 mill. tons. Towards the end of 1957, however, the refinery was processing some 1½ mill. tons and this figure has now risen to 1¾ mill. tons as the result of modifications to the equipment.

The thermal reformer has been adapted to undertake different operations from those for which it was originally designed and its place has been taken by a new catalytic reforming unit. This unit, which uses a platinum-type catalyst, takes substantially the same feed stock as the old thermal reformer but produces a higher octane petrol and gives a higher percentage yield of product. One result of its coming into operation has been that Mobil is now marketing a super quality motor spirit in the 100 octane range to meet specialised demands.

The increased throughput of crude oil has made the original jetty capacity insufficient to support the refinery's needs and early last year a new deep water jetty capable of berthing 33,000 ton tankers was constructed. An interesting feature of this new jetty is a novel hose handling system, the first of its type in this country. The hoses are wound on 18-ft. diameter reels which rotate hydraulically as the vessel rises or falls with the combination of tide and change in buoyancy of the vessel. The barge jetty has also been suitably extended.



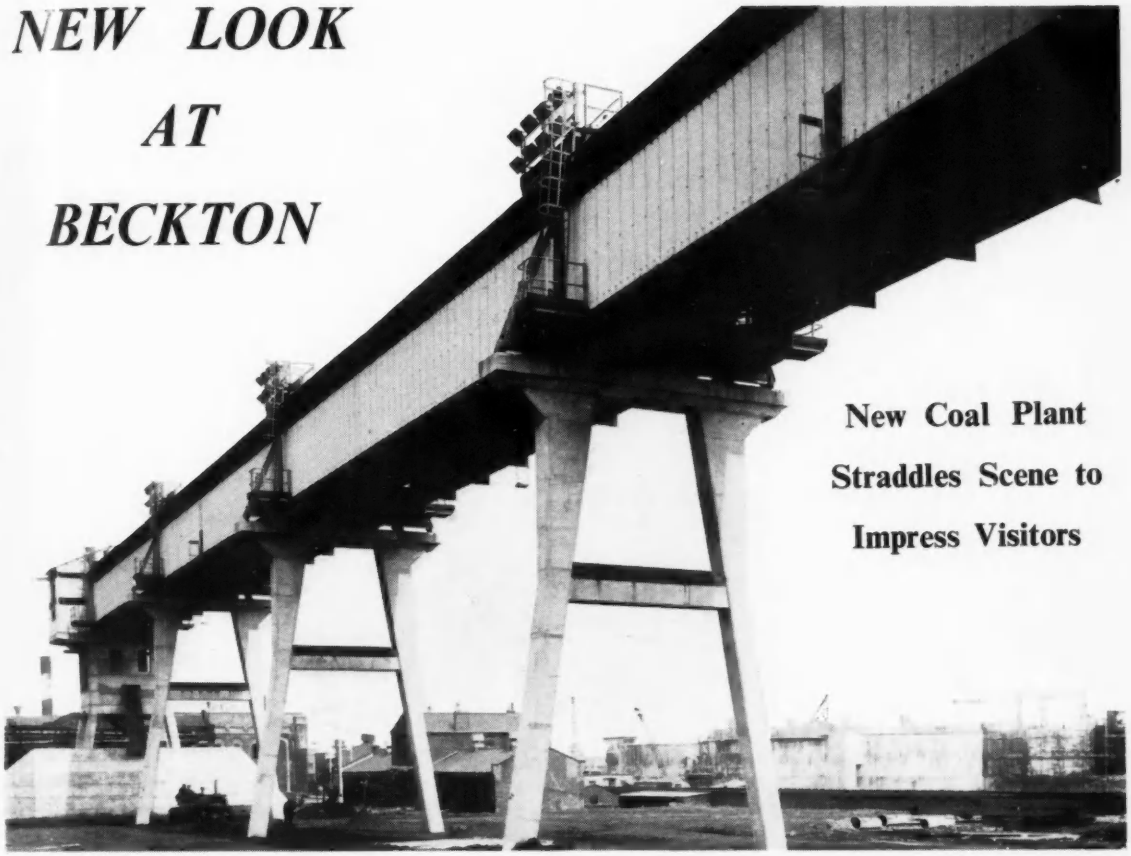
Above, the catalytic reforming unit at Mobil's Coryton refinery is now in operation. This new unit is designed to improve the quality of high-octane petrol and was completed last autumn. Below, the first stage in refining crude oil takes place in crude distillation unit. Here the crude oil is separated into a range of light and heavy distillates. The light products are used for the manufacture of motor spirit, diesel and gas oils, and the heavy ones for lubricating stock oils and fuel oils.

Last year a new technical services laboratory was completed, furnished with the latest apparatus for testing all petroleum products and fully equipped for carrying out process development work for the refinery.

At the time of the Suez crisis, all crude oil processed at Coryton was of Middle East origin. With the closing of the Canal and the cutting of the Iraq pipeline supplies were seriously curtailed.

The refinery was fortunate in holding high stocks of crude and was able to operate at nearly full throughput for the first two months. From the beginning of 1957, however, it became necessary to reduce throughput to about 60% of maximum capacity, and but for the assistance of Socony Mobil in America, the reduction would have been more severe.

NEW LOOK AT BECKTON



New Coal Plant Straddles Scene to Impress Visitors

FOR those members who had not had an opportunity of looking round the Beckton works of the North Thames Gas Board during the past 12 months or so, this year's visit must have provided a few surprises. The face of Beckton has been changing.

When the visitor to Beckton arrives at the main gate, the first thing he notices is the new stores building; a well proportioned single-storey construction, having a reinforced concrete framework, brick panelling, and barrelled roof.

This particular type of roof lends itself to the construction of such buildings since it enables large stretches of roof to be supported by the minimum of obstructions inside the building. It is divided into two main sections; one 350 ft. by 44 ft. and 30 ft. high, the other 350 ft. by 64 ft. and 20 ft. high.

The demand for coal has increased greatly since the additional batteries of coke ovens were built after the war and has made it necessary to improve and extend the coal handling, stocking, and berthing facilities.

The old pier, completed in 1924, could handle two ships of 5,000 tons at a time and unload them at a rate of 500 tons per hour. The new extension to the pier makes it possible for a third ship of 5,000 tons to be accommodated. Four extra cranes increase the rate of unloading by a further 500 tons per hour.

New belt conveyors transport the coal from this extension and form part of the new coal handling plant. Coal may be stocked by an overhead conveyor working 70 ft. above ground and distributed to a distance of 50 yards either side of the centre line by bulldozers and other mechanical handling plant.

An underground conveyor belt built beneath the main conveyor structure enables coal to be recovered from stock. Bulldozers, pushing the coal into coal feeds above this belt, make the reclaiming of coal from stock simple and inexpensive.

The main structure is carried on large reinforced concrete trestles on which the steel framework carrying the conveyor system is laid. Between each pair of these trestles is a concrete emplacement in the centre of which is a rectangular hole giving access to the underground coal reclaiming belt conveyor. The stocking ground can hold 70,000 tons of coal and the rate of the reclaiming of stock may be up to 1,600 tons per hour.

Up stream of the coal unloading pier is the coke exporting pier. Behind this is the river wall some 1,250 ft. long. It was originally constructed in 1880 and consisted of well raked wooden piles backed by 2 in. wooden camp sheeting and held in position by heavy tie rods to concrete anchor blocks.

Over the years the gradual deterioration of the camp sheeting has allowed the back filling to become exposed in many places. With this deterioration becoming serious and because of war damage, it was decided to renew the river wall.

To take full advantage of this decision a completely new wall has been constructed 110 ft. further out into the river with a gain of 3.6 acres of land to the works and greatly improved accommodation for shipping.

The design consists of A shaped monoliths constructed by superimposing between 11 and 13 prestressed concrete frames on each other and tying them together by Macalloy bars passed vertically through the sections to form a structure of about 25 ft. high. The monolith so formed was then sunk into the river bed to a depth of 2 to 3 ft. To seal the gap between the monoliths a 3 ft. diameter bored pile was inserted.

The construction of the A sections was such that three compartments were formed by transverse strengthening struts. After the monolith had been pressed into position by the application of 300 tons of kentledge, these three compartments were completely filled with lean concrete. The tops of the monoliths were brought to a uniform level by fitting a make-up unit and the whole structure was surmounted by a precast cable or pipe tunnel with a precast tie beam to link together the inshore ends of the monoliths.

With the new wall in position the space formed between it and the old wall was filled with spoil and ballast. A number of problems presented them-

selves during the placing of the monoliths among which was how to force them into position at the part of the wall which passed under No. 2 pier.

This was solved by jacking down from the pier-side members until the weight had been taken from the pier supports, placing laden trucks on the pier and following this with further jacking.

In spite of the vast size of Beckton, gas production in the most recently developed section is probably more highly concentrated than in any other works in Britain. For in the space of a few acres there are five coke oven batteries with a total capacity of 37.5 mill. cu.ft. per day and two carburetted water gas plants which have made over 50 mill. cu.ft. per day, a total of 87.5 mill. cu.ft. of gas of a c.v. of 500 B.t.u. per cu.ft.

The original coke oven batteries were built in the early 30's and after 25 years have now been rebuilt, though considerable additions to the original plant had been completed since the war.

All five batteries, which are similar, are of the Koppers compound circulation flue design. This type of oven design ensures even heating throughout the length and height of the oven wall.

With a capacity of 19 tons of coal per oven, the throughput of coal of which this plant is capable is substantial. Of the two large carburetted water gas plants, one has been built by Humphreys & Glasgow, Ltd., and the other by the Power-Gas Corporation, Ltd., but both are housed in similar buildings.

To meet exceptional demands for gas during cold spells, the North Thames Gas Board decided to install a butane-air plant which can be brought into operation at short notice and so raise the output of the works by up to 10%.

The plant consists of storage tanks and a mixing plant for blending the gasified butane and air. A site near the main entrance accommodates 12 cylindrical pressure tanks with a total working capacity of 240,000 gal., equivalent to 5 mill. cu.ft. of gas at a c.v. of 500 B.t.u. per cu.ft. contained in each tank.

This site is within easy access for pressurised road tankers bringing commercial liquid butane in from a nearby oil refinery. The butane is transferred directly from the road tankers to the storage tanks which are filled to about three quarters of their capacity.

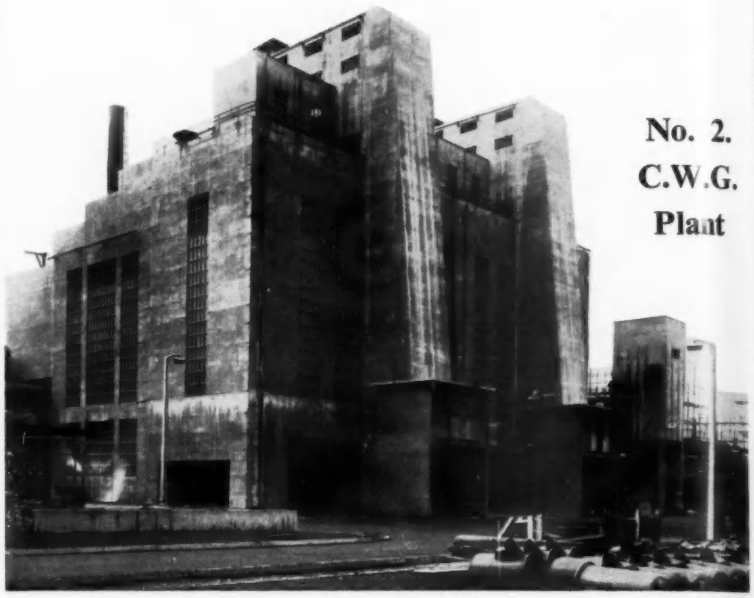
Simple contents indicating devices are fitted to the storage tanks to avoid overfilling and to show when it is necessary to change to another tank when butane is being transferred to the blending plant.

The liquid butane is fed under pressure to the blending plant by the suction to centrifugal pumps which pump it into the vaporiser. Here the temperature of the gas is raised by steam coils, and the butane, now completely gasified, is mixed with air.

At the blending plant are also installed Holmes-Connersville air blowers, electrically driven through infinitely variable gears, by which the proportion of air to butane vapour can be varied within wide limits.

The air-butane mixture enters the main gas stream at the outlet of the c.w.g. purifiers so that any variations in calorific value may be taken up by adjusting the oil consumption in the water gas plants.

Other new plant includes tower purifiers to supersede a section of ground-level box purifiers. The new plant was constructed by Henry Balfour & Co., Ltd., of Leven. The capacity of the plant is 30 mill. cu.ft. per day and its design, which incorporates the most up-to date means of mechanical handling, makes it possible to discharge and recharge the 15 tower boxes, each containing 530 cu. yards of oxide in 24 working hours.



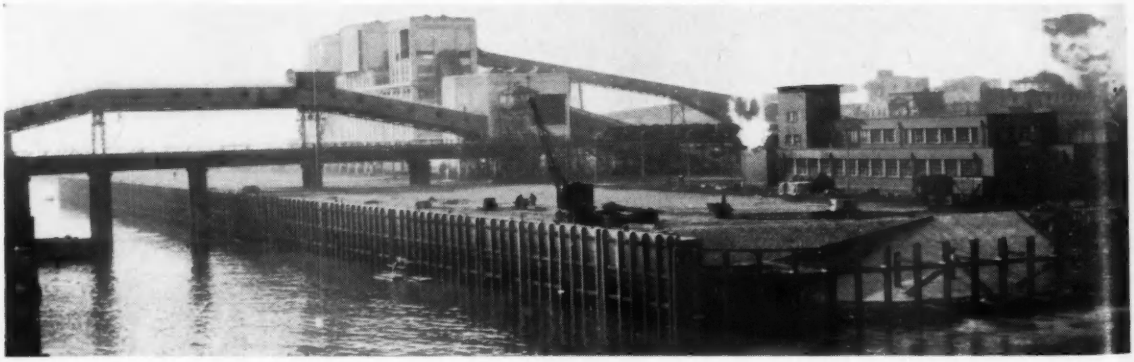
No. 2. C.W.G. Plant

It is complete with its own oxide preparation plant and connections have been arranged so that it may be used to treat 45 mill. cu.ft. per day of a gas of H_2S content of less than 50 parts per mill. by linking it to liquid purification scalping units.

A very interesting piece of plant which has been installed to treat a portion of the gas from the horizontal retort houses is a vacuum carbonate purifier plant. This consists essentially of two towers, in one of which the crude gas is washed with a sodium carbonate solution, while in the other the sodium carbonate solution is reactivated by boiling off the H_2S which it contains.

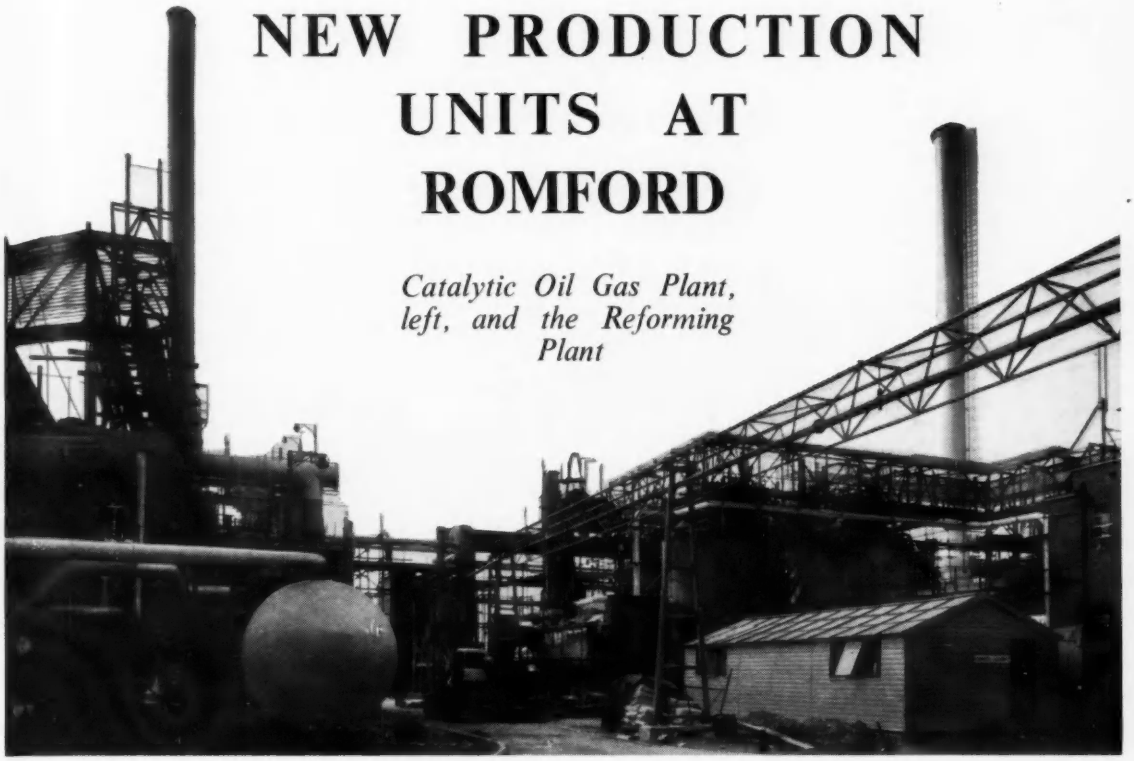
The H_2S as a gas can now be burned to recover the sulphur, either completely to SO_2 followed by further oxidation to SO_3 and the manufacture of sulphuric acid in a 'contact' acid plant, or with insufficient air to pure sulphur.

This plant, which is unique in the United Kingdom, has certain advantages among which are the comparatively small size for the throughput of gas, and the speed of H_2S recovery in the reactivating tower which works under a reduced pressure of 26 in. of vacuum.



New River Wall.

NEW PRODUCTION UNITS AT ROMFORD



Catalytic Oil Gas Plant, left, and the Reforming Plant

NEW production plant at Romford is being installed in two stages—the catalytic oil gas plant, to produce 4 mill. cu.ft. of gas per day from a range of feedstocks, including heavy oil and refinery tail gases; and the refinery gas reforming plant, to produce 36 mill. cu.ft. per day from refinery tail gases, with provision to gasify light oils.

The catalytic oil gas plant is designed on the regenerative principle, and will conserve all the heat for gas production. It is in two units, each of three main vessels, the air pre-heater with combustion chamber, the reactor containing the catalyst, and the steam pre-heater. The gas is cooled and treated in a washer scrubber, naphthalene washer and Elex. detarrer, before oxide purification for the removal of hydrogen sulphide.

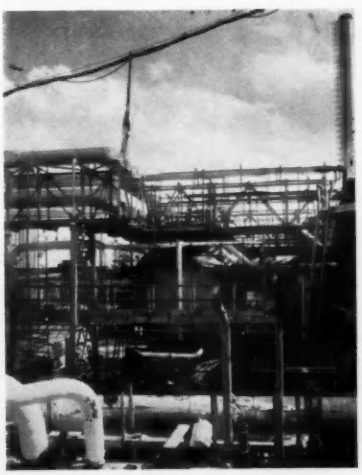
The reforming plant will reduce refinery gases of c.v. 1,400-1,500 to 500 B.t.u. per cu.ft., with combustion characteristics of gas normally sent out. It will comprise four units, each of two vessels, the steam pre-heater with combustion chamber and the reactor containing the catalyst. It is self steaming, sufficient steam being provided by waste heat boilers connected to the outlet of the reactor vessels with a surplus for other works purposes.

The gas is cooled and purified through washer scrubbers and a new installation of deep box purifiers will remove the H_2S formed in the process.

Both plants are automatically operated by the Lockheed hydraulic system on a cyclic basis, to provide a steady and continuous rate of gas production.

To provide services for them, further plant is in course of construction. This includes 200,000 gal. per day automatically operated water softening plant on the ion exchange principle; high pressure gas pumping plant, operating at 25 lb. per sq. in. to deliver gas produced into the grid system, the pumping plant consisting of two 11,000 V electric-motor driven boosters, and one diesel engine driven booster, total pumping capacity being 36 mill. cu.ft. per day; high pressure gas drying plant, operating on the outlet of the pumping plant to remove water vapour from the gas; and two spirally-guided gasholders, each of 3 mill. cu.ft. capacity in 4 lifts.

Front view of reforming plant vessels with the settling tanks and scrubbers.



Another view of reforming plant vessels and waste heat equipment.

B. C. U. R. A.

Much Work Done on Gasification

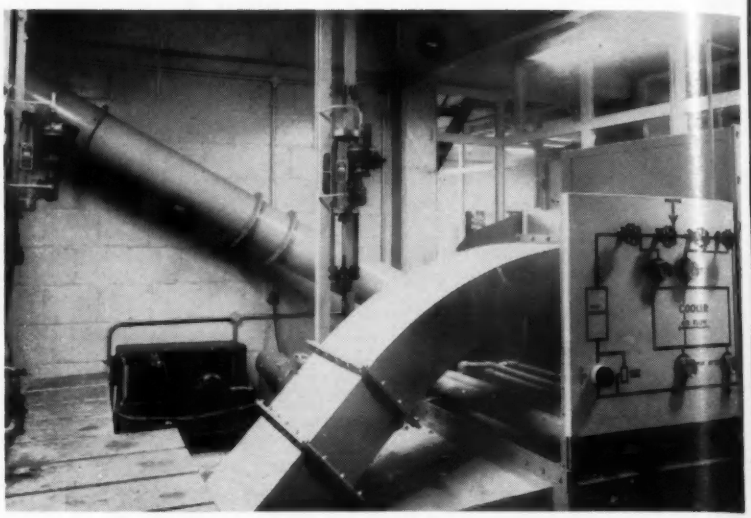
THE British Coal Utilisation Research Association research station at Leatherhead has a staff of over 300 of whom about 80 are graduates, and it is provided with equipment ranging from an infra-red spectrometer for use in chemical studies on coal structure to a slagging cyclone combustor burning up to 1,800 lb. per hour of coal, and from a particle counter for automatic sizing of dust to a full-scale Economic boiler fired by a chain-grate stoker.

Investigations are in progress under contract with the Ministry of Power into problems associated with the production of gas from low-grade coal in processes operating at high pressures and at temperatures at which the ash is liquid slag.

These problems include the tapping, quenching and removal of slag; feeding fine coal into a pressurised vessel; and the development of more efficient methods for gasifying fine, high-ash fuel. The work involves both laboratory and plant-scale investigations.

Notable equipment includes a slag viscometer and spectographic ash analysis equipment. For plant-scale investigations into slagging problems, and also investigations into the gasification of low-grade coal, a fixed-bed slagging gasifier, using oxygen/steam blast, has been designed and constructed.

Under typical operating conditions, about 190 therms per hour of gas with a c.v. of about 305 B.t.u. per cu.ft. are produced. Graded fuel is supplied to the shaft of the gasified (coke for the initial tests) and pulverised coal is injected into the slagging zone. One of the main objectives of the present investigations is to ascertain the quantity of pulverised fuel that can be gasified in a fixed bed at near atmospheric pressure.



Air recirculating and cooling system for B.C.U.R.A. calorimeter room used for testing domestic appliances.

Investigations with models at atmospheric temperature have provided useful information on the design of the gasifier. The behaviour of particles in front of the tuyeres has been studied using a model representing a slice through the centre of the gasifier in the vertical plane.

Research on gas producer practice includes work on the A.G.M. producer, a small mechanised producer consuming 150-200 lb. per hour of coal, provided with a blast superheater capable of blast preheats up to 400°C. Use is made of the Foxboro dewpoint meter for measuring the water content of the blast or hot raw gas, and of the Venturi pneumatic pyrometer which is capable of measuring gas temperatures up to 2,000°C. and is tolerant of dust.

In the boiler department, work is being carried out on an Economic boiler of the single-flue, medium-velocity type. This includes trials on the influence of coal characteristics, and the development of stoker design. Present investigations are concerned with the air distribution to the chain-grate stoker.

Two recent advances in domestic heating that have resulted from the work of the B.C.U.R.A. are the freestanding convector fire with restricted throat and the small-pipe forced-circulation central heating system.

In the physics department, investigations on coal grinding and on the counting and sizing of dust particles are in progress. The B.C.U.R.A. dust sampling probe for assessing industrial dust emissions, together with other equipment such as the centrifugal elutriator and the automatic electronic counter for dust sizing are of considerable interest in view of the Clean Air Act.

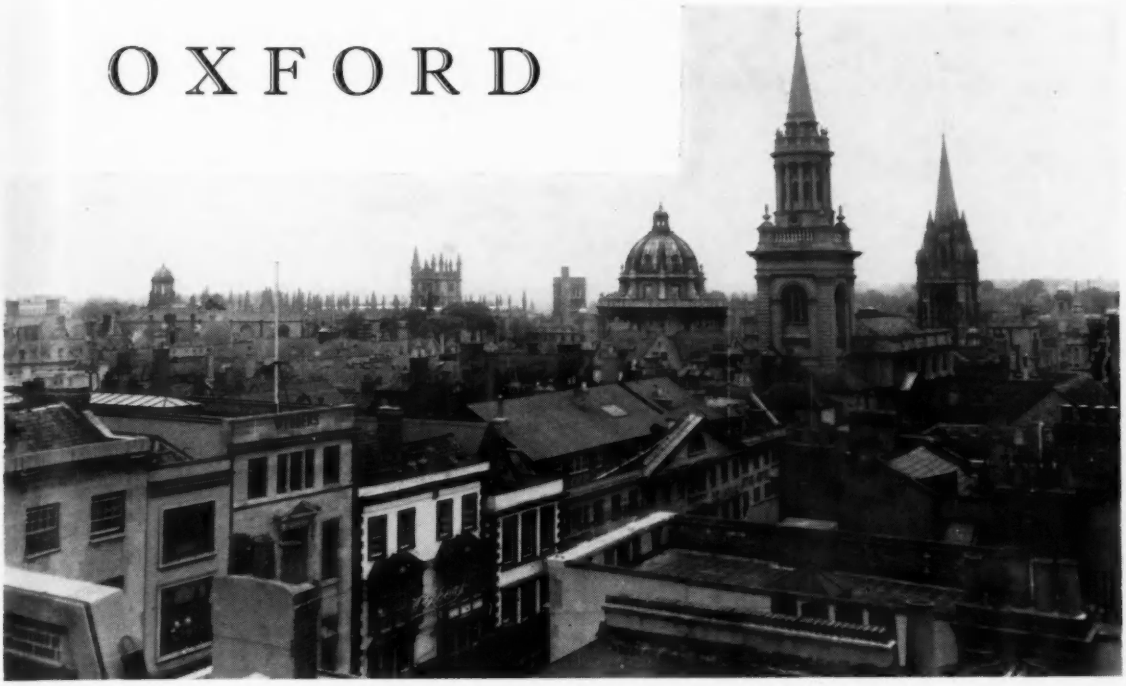
In the basic laboratories, a variety of investigations illustrate the rôle of chemistry in coal utilisation research. Work is being carried out on the chemical and physical structures of coal; on the chemical changes that take place during coal carbonisation; and on the products that can be obtained by submitting coal to various chemical treatments.

Investigations on the molecular structure of coal include the determination of quinone and hydroxyl groups by chemical and polarographic methods—the infra-red spectrometer also plays a valuable part by indicating the chemical nature of products obtained—and the use of ^{14}C as a radioactive tracer. In the constant temperature room, apparatus for studying the *micro*porous structure of coals and carbonaceous solids is in use. A mercury porosimeter is used to characterise the *macro*porous structure.

In the analytical department, apparatus includes that for X-ray measurements used to study the mineralogical structure of coals.

Dr. I. G. C. Dryden, Deputy Director of Basic Research Laboratories, right, explains chemical investigations on the mechanism of coking to Dr. A. A. Orning, U.S. Bureau of Mines, centre, during his visit to Leatherhead last month.

OXFORD



For the last day of the meeting, a visit had been arranged to the University City of Oxford, part of whose spire studded skyline is pictured above. After a quick look at some of the famous Colleges, Members lunched in one of the city's noted restaurants, and then visited historic Blenheim Palace and its world famed gardens.

My Fair Lady—a Lighthouse Lamp!

THE spectacle of a 10-kW. lighthouse lamp with flat filament the width of a man's hand, contained in a foot-diameter bulb, was among surprises awaiting visitors to the Osram lamp works of the General Electric Company at Wembley. So was a unique reflector lamp designed specially for the West End stage production of 'My Fair Lady.'

Another surprise was the news that these giant electric light bulbs have to be made by the time-honoured, skilled glass-blower—the modern machines that produce a million household bulbs a day at the Company's Doncaster associate factory just cannot cope! (And, incidentally, in this brightly-lit age, the lowly 15-W. bulb features large in the Company's business!)

The Wembley factory uses about £65,000 worth of gas a year in its annealing ovens, muffle furnaces and lamp fabricating machines. These machines are completely automatic and constant heat is needed for the fusing of the glass, which is carried out in stages.

Gas heating is unsurpassed, but the combustion characteristics must be wholly constant. This is achieved with Wobbe Index control.

Another source of interest was the precision of the automatic machine which blows the glass vessel for vacuum flasks. The careful timing by which a constant quantity of glass is withdrawn from the melting tank and the exact control of the interval during which the glass is allowed to fall under gravity before entering the mould, showed the ingenuity that went into the design of these machines.

One of the problems of lamp manufacture is the sealing of wire into glass to make a gas-tight joint. The wire must have a coefficient of expansion identical with that of glass. Such a wire is 'constantan.' If it had never been invented your household bulb would be a heavy burden on your budget—these lead-in wires would have to be made of platinum.

Life and light output of all Osram lamps are controlled by high overload testing and photometry. A sample from every batch of filaments is made into lamps and the current consumption and light output measured directly on photo-electric photometers.

They are then burnt on the high overload racks at such a voltage (about 150% of normal) that they fail in a few hours. Their lives are automatically recorded and accurately forecast the average life of the batch of filaments, which is released or rejected accordingly.

Lamps are also taken hourly from each pump and checked for current and light output. All components are closely examined at every stage and all finished lamps twice tested and examined for appearance and defects. There is also an independent inspection of 2% of all lamps which are unpacked again for the purpose.

Visitors to the Osram works were received by Mr. H. Barnet, Divisional Manager, metals division, and Mr. P. Rix, Divisional Manager, lamp works. Later at tea, they were welcomed by Mr. R. A. Woodward, Osram Services Manager, in a short speech to which Mr. R. A. Bennett replied for the Institution.

VISITORS SEE OLDEST AND NEWEST

While Touring

Gothic Works

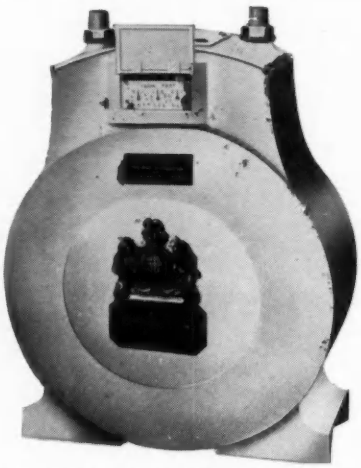
ONE of the high-lights of the visit by Members of the Institution to the Glover & Main Gothic Works at Edmonton was the No. 1 Glover dry meter illustrated on this page, the first meter to be fitted with Glover slide valves.

Made in 1844, the No. 1 was sold to the old Coventry Gas Company and repurchased by Thomas Glover & Co., Ltd., in 1896 after completing 52 years' service. Now 114 years old and still in perfect working order, it was shown alongside the last Thomas Glover meter to be completed before the visitors arrived (also pictured on this page).

The visitors, who were taken on a comprehensive tour of the Thomas Glover, R. & A. Main, and Main Enamel Manufacturing Company's factories, were welcomed and accompanied by Mr. P. D. M. Aird, Deputy Chairman, Glover & Main, Ltd.; Mr. C. Marley, Director, Glover & Main, Ltd.; Mr. W. K. Tate, Managing Director, Thomas Glover & Co., Ltd.; Mr. C. A. Macleod, Sales Director, R. & A. Main, Ltd.; Dr. B. R. Niklewski, Managing Director, Main Enamel Manufacturing Co., Ltd.; Mr. G. F. Jenkins, Director, Main Water Heaters, Ltd.; Mr. J. Wortley, General Manager, R. & A. Main, Ltd.; and Mr. S. A. King, General Sales Manager R. & A. Main, Ltd.

The visitors' tour of each factory had been most carefully planned to enable them to see the maximum number of departments in the time available.

Commencing in the Thomas Glover works, the guests were shown the fabrication of modern gas meters ranging in size from small prepayment types of 100 cu.ft. per hour capacity to large industrial meters with a capacity of up to 50,000 cu.ft. per hour.



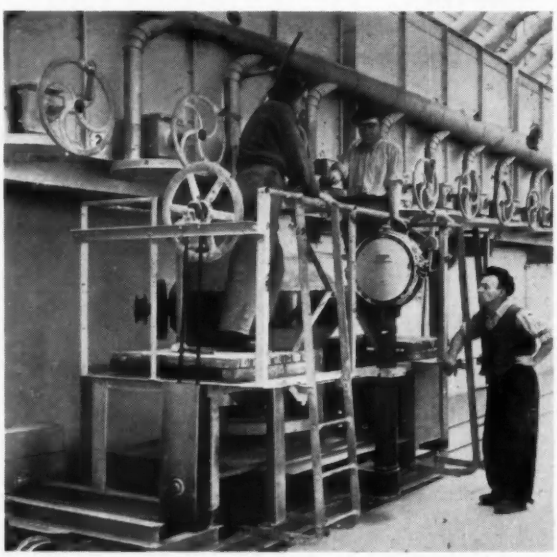
Pictured above is No. 1 Glover dry meter made in 1844—below, the latest to come off the assembly line.

This was followed by a tour of the Main Enamel Manufacturing Company's factory to watch the manufacture of the high quality vitreous enamel frits and colouring oxides produced for use not only for R. & A. Main, Ltd., but also for many other firms both in this country and abroad.

Finally the parties visited the R. & A. Main factory where they were able to watch the complete cycle of operation in the manufacture of the range of Main appliances produced at Edmonton.

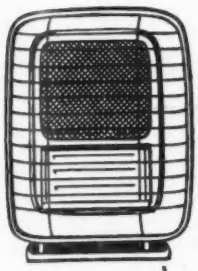
In addition to domestic gas appliances, ranging from single boiling burners to the Super Century cooker and No. 36 refrigerator, this factory also produces a wide range of heavy duty apparatus for the catering and allied trades, and this section of the route included a visit to the recently opened heavy apparatus showroom where a representative selection of Main catering equipment was displayed.

On completion of the tour, refreshments were served and the visitors were also able to inspect a comprehensive display of the appliances produced by the Glover & Main Group of Companies. This display, in addition to featuring the products manufactured at Edmonton, included the latest Main main water heaters from Gothic Works, Croydon, fires and space heaters produced at Gothic Works, Falkirk, and home laundry appliances manufactured by Morley Products (Padiham), Ltd.



Seen, left, in the enamel works, is the dual purpose weighing and mixing container, fed direct from hoppers with the ingredients, in correct proportions, of frit, basis of vitreous enamels. Right, in this section of the fitting shop Main cookers are seen in their final stages of manufacture.

TRITON Instantaneous Water Heater



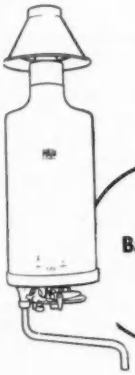
ROMANY Transportable Fire

SUPER CENTURY COOKER

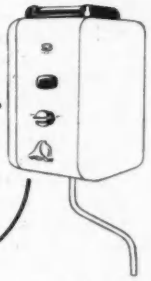
The name's the same

for all the best

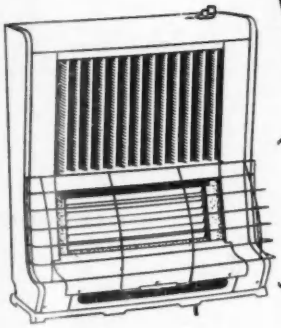
GAS APPLIANCES



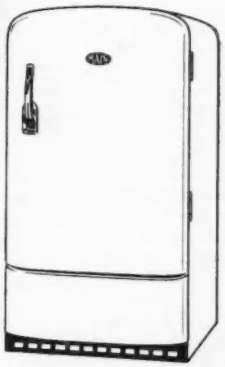
JASON Bath Water Heater



ADONIS Sink Water Heater



No. 271 CENTURY HEATER



No. 36 REFRIGERATOR

Note the name - made by MAIN

R. & A. MAIN LIMITED LONDON and FALKIRK

95th A.G.M. — a 'GAS JOURNAL' Abstract

COMM. No. 526 AND DISCUSSION

Domestic Marketing:

—comment and conjecture

by J. A. BUCKLEY, *Assoc.M.Inst.Gas E., A.M.I.Mech.E.*,

DIVISIONAL MANAGER, EASTERN DIVISION,
NORTH THAMES GAS BOARD.

THE term 'marketing' can be taken to cover a wide range of activities, all of which, when co-ordinated, direct a satisfactory flow of goods and services to the consumer. In the gas industry, these activities include market research, public relations, sales, consumer service, warehousing, office services, and, so far as the day-to-day supply is concerned, distribution. This review deals with the five main domestic gas heat services, and is written with the accent on 'sales,' the feature of marketing that needs particular attention today; the other specialised activities demand separate treatment if they are to be dealt with fully. In addition to arriving at the actual cost per therm, both the thermal efficiency and efficiency of use must be allowed for, in which the suitability of the appliance and installation and its flexibility of operation must play a very big part. Also, it is often necessary to take into account the methods of payment for the fuel before assessing the consumer's attitude to prices.

Replacement

The gas cooker is the sheet anchor of the domestic gas load, and it is also important to realise that, in many areas, cooker sales amount to more than half of the total value of all domestic gas appliances sold. It may be argued that the industry's dependence on the cooker is a disadvantage and that a greater diversification would be healthier; on the other hand, the cooker can be regarded as the corner stone around which the other heat services may be added to provide a desirable load. The Eastern Division of the North Thames Gas Board served an average of 295,000 domestic consumers during the period 1951-57, and, if it is assumed that an average of 85% of these consumers used a gas cooker, it can be shown that a maximum average of new cookers was purchased at a rate of nearly one every 10 years of service of all cookers installed, and a minimum of one every 18 years, the mean being a figure of approximately one every 14 years. It is essential to strive for a continuous average replacement rate of one cooker every 10 to 11 years. Both the appliance manufacturers and the Board's selling organisations have important responsibilities in this matter. It is particularly interesting to consider cooker business in relation to new housing. Although the present rate of cooker sales may be inadequate to secure the future, the gas cooker has, by and large, maintained its popularity in comparison with its competitor in council housing.

In considering space heating, one problem that has exercised, and continues to exercise, a marked effect on commercial policy is the extremely high cost of providing for peak-load supply . It has been shown that the cost of producing a therm of peak-load gas was 13 or 14 times as high as that of a therm of base-load gas. However, since the high cost of peak production occurs only for such relatively short periods, the increased cost of gas spread over the total space-heating load may be no more than ¼d. per therm, and substantially less when related to total gas output. Any justifiable differential for winter/summer prices of gas, therefore, would be far too small to affect the competitive position substantially in respect of summer loads. Running costs of the high-efficiency convector/radiant gas fire are now competitive with solid fuel, particularly where gas is purchased at promotional tariff rates. In convenience, comfort, and appearance, the modern gas fire is surely second to none. A really determined effort should therefore be made to secure the main living-room heating by gas. This is one of the most effective ways of securing an immediate increase in domestic gas consumption.

It also is clear that a substantial domestic market for coke and other processed solid fuels is becoming available in replacement of the burning of raw coal. The gas industry must take the fullest possible opportunity provided by the Clean Air Act and clean air publicity generally to sell its wares, for it may not for a long time again be presented with so favourable an influence. Where the industry cannot succeed with the convector gas fire, it certainly should with the gas and coke combination, or the gas-ignited coke grate. The forced-convection gas heaters recently marketed have substantial advantages in both first cost and flexibility over the conventional hot water central heating system, although the gas central heating boiler combined with a well designed heating system is difficult to match as a trouble-free and excellent heating service. The gas air heater, however, should open up two new fields for gas heating in which the gas central heating boiler may not be acceptable on cost grounds: First, to a much wider income range of domestic consumer, by using a heater designed to give background warmth only, or selective full heating to one or more rooms; secondly, as a really attractive heating system for offices, certain shops and other 'semi-domestic' premises. To advocate increasing use of gas for space-heating services might seem an illogical approach to the seasonal peak-load problem, but it has been shown by Burns and Clark that a doubling of the whole space heating load in the North Thames area would only increase peak-load costs by less than ¼d. a therm. The industry should, therefore, seek to work through this peak-load problem by obtaining a maximum of those heating loads that are spread over the entire heating season, and securing such a general increase of consumption that the peaks become less noticeable in relation to the generally increased winter demand.

Difficulty

The value of domestic water heating needs no emphasis, although the precise load value of each category of appliance is difficult to assess, for such statistics as have been published show a wide variance and have not agreed with estimates based on expected hot water requirements. This difficulty is particularly marked in the

case of the sink heater, which often replaces a considerable part of the use of the 'kettle' on the cooker hotplate. The main competitor in this field is electricity, and the immersion heater in its various forms is the principal appliance concerned. Immersion-heater saturation now probably approaches 20% of households, although a proportion of these are fitted without thermostats and something like half may be in use in existing hot water cylinders without lagging. The great advantage that gas appliances have in competition with the electric immersion heater is speed and flexibility, and a large potential market still exists for the instantaneous gas sink heater where immersion heaters are installed. There are three major factors which continue to require the gas industry's urgent attention in the development of the instantaneous heater. These are temperature rise, flueing and maintenance.

Much has already been written and said on the subject of sulphur removal. In the North Thames Gas Board's Area, considerable progress is being made by the production department, and the average sulphur content has been reduced progressively from approximately 30 to 16 grains (average) per 100 cu.ft., whereas in certain areas of the Eastern Division consistent deliveries of gas of no more than 10 to 11 grains sulphur are now being made. This has enabled a reduction in the frequency of cleaning instantaneous heaters to be considered. In the Eastern Division alone, the reduction could result in a direct saving of some £14,000 per annum. In addition, there is likely to be a substantial saving on request calls and, if the policy were adopted universally, a considerable economy in appliance production costs.

Popularity

There has been a general consumer desire to acquire labour-saving and automatic appliances, as evidenced by the popularity of power-driven washing-machines, wringers and driers, but heavy purchase tax and restricted hire-purchase terms have weighed heavily on motor-driven appliances. With rising costs of labour, finished-laundry charges have increased considerably, and the launderette has made its appearance and quickly become established. The gas wash-boiler, which has been improved in style and performance, but remains substantially the same basic appliance as its pre-war counterpart, continues to enjoy a prolonged popularity largely due to its relative exemption from purchase tax and restrictive terms. A number of types of gas/electric washing-machines were developed and, at the time of coming on to the market, achieved very definite popularity. Unfortunately, this occurred when no fewer than three radical changes in hire-purchase control occurred in the space of a year; nevertheless, the appliance established itself, and sales, through at a disappointingly low level, have been maintained. Three points have emerged from selling experience: The value of showroom window demonstrations for initiating sales, the satisfactory number of recommendations to friends and neighbours that occur and promote additional business, and the assistance to sales that a method of collection of the hire-purchase initial payment by instalments would provide. Unfortunately, the gas industry does not appear able to go as far in the latter direction as do some of its private electrical trader competitors, although the introduction of credit sale terms has been helpful. Simultaneous with the decline of sales of the gas/electric washing-machine, increasing business was obtained by the convertible wash-boiler—the basic wash-boiler to which may be added the hand-operated wringer and agitator. The limited space available in kitchens, together with heavy purchase tax, have stifled the development and sale of the gas drying cabinet. Electrical spin and tumbler driers are increasing in popularity, and the development of either a portable gas drier, using natural convection, or a forced-convection gas drier of modest size, seems necessary.

Refrigeration is a most desirable load, its additional annual value being more than 50 therms per appliance, and the market is still largely unsatisfied. It is estimated that no more than 8% of electricity consumers in the United Kingdom own electric refrigerators, which compares with 6% of North Thames consumers who possess gas models. The gas industry has concentrated upon the retailing of cabinets of approximately 2 cu.ft. capacity, and in view of the high initial cost of these appliances, this policy appears to be sound.

The framing of promotional tariffs is of great importance to the success of building up the space heating load. There appears to be no uniform approach to the design of tariffs by area gas boards, but this, in itself, may be beneficial, for it should provide the greatest opportunity for experiment and experience. In the North Thames area, the two-part critical consumption for domestic consumers is in the region of 230 to 240 therms per annum, the commodity rate being nearly 6d. a therm less than the flat rate, a reduction of approximately 23%. There are also possibilities in the consideration of a combined gas and coke tariff. There are many thousands of consumers obtaining a heat service by the combination of 150 to 200 therms of gas, plus 35 to 40 cwt. of coke per annum, and a special price incentive for the continued improvement of this combination should be of value.

Sales Direction

Sales of gas water heaters, space heaters, refrigerators and washing-machines have undergone more variation, due to external factors, than almost any other form of domestic article during the past 10 years. It may be remembered that hire-purchase terms for water heaters have been changed four times since 1951, and that purchase tax has suffered six changes since 1947. As an illustration of the violent fluctuation in sales to domestic consumers that has occurred: In 1952, sales of sink heaters in the Eastern Division amounted to 1,100, whereas, only two years later, the figure rose to 10,400.

Sales direction needs to be more vigorous and flexible today than ever before; certainly, the need is as great as in the early and middle 1930's. What tactics then should be pursued? The first, recently implemented, is the co-ordination of mass advertising with uniform selling prices and universal sales campaigns. Sales campaigns require a great deal of preparation and effort, for it is not sufficient to 'leave' it to the advertising and window displays.

There is the 'special offer' technique, for virtually everyone is susceptible at one time or another to its attraction. This particular weapon should not be misused, or it will result in the customer thinking, if not asking, why the price cannot be reduced. Finally, and in the last analysis, the result rests with the enthusiasm of the sales staff. Enthusiasm can be induced to some extent by leadership and encouragement from supervisors and managers, and by a cash incentive.

Specialisation

The importance of market research to management is now established beyond doubt. Its application to the gas industry has already been fully dealt with. Market research is an intelligence system giving information which, when assessed, provides a basis for future policy not only in sales, but in all other aspects of consumer relationships. The marketing field is so wide that specialisation is essential. In North Thames districts, separate supervisors cover sales, service and offices services respectively, and the detailed application of their work calls for special experience and techniques with functions falling within well defined spheres. Specialisation gives advantage in the field of cost control, as comparative costs and other statistics enable time to be concentrated on the exceptionally weak or costly components. Home service staff are an invaluable part of the marketing organisation and have a variety of unique contributions to make. These vary from the service given in the homes of consumers, ensuring that the best results are being obtained from appliances, to demonstration selling in showrooms and at exhibitions. In order to facilitate the collection of charges from tenants of housing authorities, the Board agreed to the payment of a small commission to those authorities in return for the weekly collection of hire-purchase payments, two-part rate standing charges and hire rentals by the weekly house rent collectors. This arrangement soon proved to be a potent sales weapon, as many tenants prefer to pay hire purchase accounts weekly and appeared to be more readily able to acquire modern appliances in this way.

Rising overhead costs have made it necessary to review the economics of some smaller fitters' depôts, which, although well serving their purpose in the past, appear to be unduly costly today. Certain fixed charges obtain that cannot be made proportional to the size of depôt. An answer to this problem has

been the introduction of mobile depôts, which have been specially designed at the Board's Transport Centre, and are driven by a gas fitter foreman. The unit is attached to a parent depôt where clerks prepare work books to the foreman's instructions, which, after checking, are issued to the fitters at a recognised daily 'meet.' The judicious siting of meeting-places has resulted in a reduction of fitters' travelling time, while the foreman has the added advantage of mobility for his supervisory work during the remainder of the day.

Special attention has been given to methods of dealing with calls received outside normal hours. There are three significant aspects of this work:—

(1) The limited number of requests; (2) the importance of these calls; (3) the costly nature of local emergency arrangements.

The above three factors have been taken into consideration in the development of the Board's Radio Temgas night emergency organisation based on the division as a unit. A central night service office is manned by a night service officer, who controls two radio-equipped light vans driven by special shift fitters. A further interesting economy has been possible that takes advantage of the fact that the number of calls received falls away very sharply after 11 p.m., for no more than an average of five per week per mill. customers are received between 11 p.m. and 7 a.m. Special G.P.O. equipment has been installed to enable all calls made to the Eastern Division between 11 p.m. and 7 a.m. to be automatically relayed to Westminster (Central Division), which has enabled the 11 p.m. to 7 a.m. night service officer's shift at Ilford to be abolished. The night service officer at Westminster has the same radio control over the Eastern Division emergency organisation during this period as that previously exercised at Ilford.

Saturday Shopping

The showrooms' function as a direct-selling point is not diminished, but increased, by the activities of district representatives, canvassing representatives, dealers and non-selling staff. The value of well-lit showrooms with open interiors and modern fitments is well established and there are some excellent examples in the Board's Area. Window display is a specialist job, and the Board's display section has produced excellent examples of really attractive displays, designed to support national or regional sales campaigns, and of sizes suitable for regular rotation between different showrooms.

The efficient and tidy stocking in showrooms of the variety of small parts, fire radiants, tubes and fittings is important. It is also necessary, in these days of high labour and transport costs, to encourage consumers to use the local showroom as 'service' centres for minor repairs and replacements. The post-war period has seen an intensification of Saturday shopping. More than twice the number of customers are dealt with in most of the showrooms in the Eastern Division on Saturday than on any other day, and the ability to meet peaks of business economically, due both to this and other reasons, is certainly a problem. The introduction of self service coke ordering has been of great assistance, and experience has proved it to be popular with the public. Another development first seen in the Liverpool Undertaking and with the same object, is the installation of a consumers' service telephone directly linked to a service and fitting depôt, which may be on the same premises or may be several miles away. This is most popular also on Saturdays and at other peak periods. The Board's mobile showrooms have proved their value many times over, versatility being their great asset. Their work varies from regular attendance at housing authority estates letting days, to visiting outlying areas remote from showrooms. The North Thames Authorised Dealers' Scheme followed naturally from a successful scheme initiated by the Gas Light and Coke Company before the War, but had to be largely reorganised because of the lapse of selling during the war period and of the shortage of appliances that ensued in the immediate post-War years.

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DISCUSSION

Opening the discussion, **Mr. A. F. Hetherington** (Southern Gas Board), said the author rightly pointed out that cooker sales gave no grounds for complacency. One could understand manufacturers being reluctant to displace a model which was selling well and it was disappointing to find that some new appliances bore some signs of hasty improvisation. Did the housewife dream of more and more gadgets, or fewer and fewer? As an industry they did too little market research.

'In Table 2 of the paper, went on Mr. Hetherington, 'the sales value of a water heater installed in a new house by the builder is so strikingly shown that one is tempted to embark on the slippery slope of subsidising. It would certainly seem, from the figures given, that a subsidy on the installation of a water heater in a new house might prove a very cheap way of selling other appliances.

'I was very glad to read the remarks on space heating and particularly the consumptions to be expected from living room convector fires. If one allows for some use of a turn-down rate, it would seem that a typical fire is being used for something approaching 1,000 hours a year and I, at any rate, do not consider this a peak load. It seems clear that the heating of the living room of a house is the most important single new field open to us. The price of gas is now nearer to the price of coal than it has ever been and yet sales are slow in coming in. Has the author any particular sales suggestion to make?

'Of course, refrigerators are an obvious way of improving our load and I think we have all seen indications that we are now in for a boom in these appliances. I think perhaps if we want new developments we must look for other fields. There are quite sizeable off-peak loads in the United States which scarcely exist in this country and I should like to feel that our "foreign affairs" coverage was as good in commercial matters as it is in distribution and production.

'The continued development of traditional appliances is, of course, just as important. At the author points out, we still have no thermostatic control on instantaneous water heaters, something which is now long overdue. Although fires have improved greatly recently I think there is still a need for more attention to be paid to controlling the rate of air change induced in a room.

'There is one very striking omission from the paper and that omission is, I think, a great tribute to the North Thames distribution system. Nowhere in the paper does the author refer to the need for a proper and uniform pressure of gas and I presume that that is because he is not worried about it. If the distribution system is not adequate I would put it at the top of the priorities because without it we are wasting our time in talking of marketing.

Complaints Halved

'The author makes some very pertinent remarks about the sulphur content of gas, and we heard a lot about this yesterday. Last December we closed down the local works at Salisbury and took in a piped supply from Southampton and overnight the sulphur content of the gas fell from 30 plus grains to 12 grains. It is too soon to draw any firm conclusions from that but it appears at the moment that customers' complaints have been halved.

'I should like to make one comment only on the admirable customer service section of the paper. Has the author tried sending job tickets to and from the fitter by post rather than having a daily meeting at a mobile depot? I think this can be a real money saver in rural areas.

'I could have wished that the author had dealt more fully with tariffs, which are so important to us, but I echo his remark that no tariff, however good, promotes the sale of gas. All it does is to enable the salesman to promote it. I could also have wished that he had said a little more about dealers because I am convinced that we must take these very seriously indeed.'

Mr. G. H. W. Madge (Assistant Commercial Manager, North Thames Gas Board), said Mr. Buckley's paper contained an excellent definition of marketing as understood in the gas industry. There was sound comment, too, on the vital questions of prices and payment as they affect the use of gas. He made

Left to right: Mr. J. Bennetts and Mr. R. J. Atkin, Northampton; Mr. A. P. Searth, Staveley; Mr. E. B. Craddock, Northampton; and Mr. F. B. Halliwell, Leicester.

quite a distinction between price and payment which was essential.

'On cooking, surely nobody will quarrel with the description of the gas cooker as the sheet anchor of the domestic load, and nobody will study Fig. 1, showing quarterly cooker sales for the past seven years, without considerable disquiet,' went on Mr. Madge. 'The reasons for the unsatisfactory sales levels recently recorded are fairly explained and evidence is provided of the energetic sales effort necessary to achieve even such modest figures. The author makes no direct mention, however, of the competition of the electric cooker which has grown disproportionately of recent years with the availability of much improved models at popular prices. For all its good points the modern electric cooker lacks many of the advantages of the gas cooker, especially speed and flexibility, but the gap has been reduced and that is very important.

'The author's emphasis on the necessity of a sense of urgency in gas cooker development is timely, but I am sure that he would be the first to agree that manufacturers undertaking the heavy expense involved in the production of new models must be reasonably assured of a share in a larger market than that of the past few years. To this end we must achieve a higher rate of cooker replacement than at present, and the author's remarks on this subject are of value.

'On new housing, the figures recorded in Table 1 on p. 6* of the paper showing the percentage of gas cookers installed at occupation are superficially satisfactory, but the decline in the results of private development housing, to which attention is drawn, calls for sober reflection. The remarks on the value of mutually supporting services are shown strikingly in Table 2 on p. 7 of the paper. There does appear to be a *prima facie* case for a completely fresh approach to the task of selling hot water appliances, and possibly others as well. That is what the last speaker called the slippery slope of subsidy.

'I found the chapter on space heating to be one of absorbing interest. No doubt many others in this hall share my satisfaction that this erring daughter of the industry, now safely married to the task of providing all the year round heating, is happily back in the bosom of the family. Surely space heating more than anything else can bring a new prosperity to the industry, as cooking did a couple of generations ago.

'The author has not allowed his enthusiasm for gas to obscure the fact that we are still a two fuel industry. Our second product, coke, is currently facing more severe competition than hitherto from oil and from refined solid fuels. Mention is made of the favourable circumstances of the present market, including the opportunities provided by the Clean Air Act, but I do not think it will be denied that coke, like gas, has got to be sold and that our traditional marketing methods need revision to this end.

'The gas air heater, capable of giving background warmth throughout the house or full heating to a part of it at the user's option, is certainly one of the most promising developments of recent years, especially for new housing projects.

'Good points are made in the paper on the vital question of flueing. We all know to our cost how fatally easy the situation becomes for our competitor, electricity, once flues are excluded from the architect's scheme. The situation as described by the author on the subject of paraffin heaters has improved a little since the Budget, but while I agree with his plea for still further reducing the sulphur content in gas, for many reasons I do not envisage, as a result, a vast increase in the use of unflued gas for domestic space heating.

'A very clear picture is given in the paper of the great inroads made by the electric immersion heater into the potential, if not the actual, field for gas water heating. The author, however, rightly has great faith in the instantaneous gas water heater subject to some constructive criticism with which I, for one, would agree. Mr. Hetherington mentioned thermostatic control, and that has been one of my hobby horses for years.

'On sulphur the author's remarks are brief and to the point. In effect he is saying "Sulphur must go," and so say all of us.

Ideas Changed

'The first paragraph in the paper on refrigeration, succinctly expresses the great value of the gas refrigerator as a load builder. The three graphs, Figs. 3, 4 and 5 on pages 17, 18 and 19 of the paper show very clearly the marked effect of temperature on refrigerator sales, hitherto thought to be the most seasonal of all appliances. I say "hitherto" because although it is still seasonal some of our ideas have changed a little during the past winter. During the past winter, helped admittedly by the availability of a new popular priced refrigerator, we have achieved remarkably high sales. There are signs that households now equipped with the first necessity of a television may adopt the refrigerator as the next necessity to be purchased.

'The author flirts with the attractive idea of a combined gas and coke tariff. I do hope that it will not have to be included in the list of those desirable things which are either immoral, fattening or illegal!

'I think that we all share the author's concern about the depressive effect of frequent changes of tax and credit control. We must beware, however, of using these unholy twins as a permanent alibi for low sales. After all, motor cars and television sets sell in vast numbers despite the handicap.

'The author rightly says that sales direction needs to be more vigorous and flexible today than ever before. He goes on to show some of the things which are being done to meet that need. I think

* Page numbers are given so that original texts may be referred to.

it only fair to say that in his Division those things are done remarkably well.

'A sound basis for dealer business is expressed in the paper, and the author declares the intention of increasing this business greatly. We are indeed doing our best to foster the use not only of dealers' premises, which provide such valuable additional retail sales points, but the employment under suitable control of canvassing dealers who, we are convinced, can provide us with a great deal of business.

'One cannot fault the author on his four conclusions. I believe wholeheartedly with him that in the last analysis success largely depends on the personal enthusiasm that sales and service staffs bring to their daily contacts with consumers.'

Mr. L. W. Andrew (Watson House): 'I welcome this paper very much indeed for many reasons. It is good that the author, in talking of the interdependence of the various gas loads, points out that we cannot live by the cooker alone. The cooker cannot live, and we cannot live, if we depend on that one load, and our research and development policy is based on giving priority to all the heating services.

'The author has mentioned the effect of capital cost on sales. That is a very real problem, but it is not possible, for example, to make a high efficiency convector fire at the same capital cost as a small bedrom panel fire and I think we must accept the fact, and educate ourselves to believe, that it is the total cost which matters, which includes the capital, installation, maintenance and running costs. The capital cost may be dominant in the cooker, but when we are talking about the space heating load in the living room, say, 200 to 250 therms a year, then clearly the running cost will have an enormous effect on the extent to which the user is satisfied ultimately with the service he is getting.

Realistic View

'I was delighted to see, on p. 6 of the paper, that the author takes such a realistic view concerning the encouragement and development of new types of appliance, even when these are somewhat more complex in design than was necessary in the days when the competition from electricity was less keen and gas could be sold merely because it was cheaper than other fuels. Such factors as the wider use of automatic ignition and the use of electricity as a helpful ancillary to gas cookers, air heaters and laundry equipment place a new emphasis on maintenance service and after-sales service. We do everything possible to ensure the soundness of a new design, but in the early days let us not niggle. We must meet the manufacturers at least half-way in these new developments and on our side we want to provide the user with a service and not just an appliance. I am sure that the author is right when he regards the enthusiasm of the salesman as one of the major factors in selling more gas. I should like to add a firm proviso here. I believe that that enthusiasm must be backed up with real conviction, and in turn that conviction must be based on a proper understanding of the real technical merits and competitive position of the appliance being sold.

'It seems worth while obtaining more and more practical gas consumption figures, particularly for space heating and water heating, in order to break into new and legitimate fields. We have a wonderful story to tell and one of our major concerns at Watson House is to provide more and more evidence to ensure that the gas industry really believes in its own strength and can therefore convince other people.

'Over the last few years everybody has become enthusiastic about space heating by gas and the manufacturing side of the industry has accepted the supply of such a heat service, in spite of peak load problems, as a necessary part of the industry's contribution to smokeless air and better living, and an increased gas load. Whilst accepting the importance of the load in new buildings and new blocks of flats, I personally covet most the existing millions of ordinary flues which are still being used for open coal fires. It is unfortunate that the flues and fireplaces are ridiculous objects which are not designed for modern gas appliances but the flues are there and they are going to be our flues. In the flue in the living room we must go all out for the high efficiency convector fire, but it must be installed properly and not just stuck in front of the fireplace. A fire is satisfactory now if fitted in accordance with the maker's instruction, but considerable experimental work continues, to assess the simplest and most reliable method of ensuring adequate but not excessive ventilation. It is important that the user should be instructed in the proper use of any space heating appliance, whether it is an air heater or a living room fire. The user must also have a reasonable idea of the overall consumption to be expected and the consumption they may have to face up to in the really cold weather. With some of our imaginative two-part tariffs this large domestic consumption is potentially competitive with other fuels, but if we do not tell them what consumption to expect they may get a shock.

'On air heating the commercial possibilities are real, but people must know how to use the system and what to expect from it. Here perhaps the author may feel that there is room for more and more specialists in the installation of such appliances. Basically those experts will be inside the gas industry, but there may be an opportunity for a closer link up with heating and ventilating engineers because they themselves are showing an increasing interest in this method of heating domestic houses.

Independent Control

'In our enthusiasm for space heating let us not forget our wonderful friend, to whom we pay tribute over the years, gas water heating. Someone pointed out to me the other day that in the case of a block of flats with central services where coke is used for central heating, it should not break our hearts if the water heating was done by gas under independent control. Since the war there have been many experiments in central services in blocks of flats in the middle income group. Many of those schemes, where the tenant pays for the heating services, have broken down because of excessive use and the charges have had to be increased. An analysis of the figures show that almost invariably the source of the excessive waste was the water consumption. Space heating can be wasted, but it is even easier to use domestic hot water extravagantly.'

In thanking the author for his paper, the speaker concluded by saying that he looked forward, by intelligent selling, to a target not of 100 to 150 therms per house, but of 350 to 400 therms per house per annum.

Mr. G. W. Phillips (Eastern Gas Board) said there was in the paper a significant reference to the effect of the nuclear energy programme on the electrical industry's publicity and a plea to give greater publicity to modern technical development in gas production and distribution. Nowadays it was quite common to see references in the Press,

Left to right: Mr. G. G. Holmes, Hastings; Mr. S. W. Hammond, Eastbourne; and Mr. H. Rowland, Horsham.

Mr. T. A. Tomlinson, West's Gas; Mr. T. Biddulph Smith, Partington; Mr. L. S. James, Electroflo.

and these appeared to be occurring at an increasing rate, to the nuclear energy programme, either in the form of Press reports concerning statements made by a high authority on this matter or in the form of a prestige advertisement of one of the mammoth combines which were involved in this programme. It was vital that the industry met this challenge with suitable counter-publicity on the lines suggested by the author, which at the same time did not try to detract from nuclear energy the rightful place which it had in the pattern for the future fuel supplies of the nation.

Mr. Phillips continued: 'The author refers, in a very gentlemanly way, to arguments that have been centred around the merits of the space heating load. With very great respect to the eminent authors of the paper on peak load costs mentioned in the present paper, surely the important points to remember are these. First, many of the appliances which produce the peak load also consume gas to a lesser extent during a considerable proportion of the heating season and, therefore, any action taken to discriminate against the peak load appliance may jeopardise the longer period heating. Do not let us forget that one of the culprits producing peak load space heating at very low atmospheric temperatures is the gas cooker which is lighted up at such times to heat the kitchen and perhaps other parts of the house. Any fitter or meter reader will confirm this fact.

Secondly, surely we are selling a service and we cannot in our approach to our customers put on any artificial restriction to one of the most important of those services.

'The figures given on the "added load" of the sink heater taken from a sample of 107 consumers on the L.C.C. estate at Becontree are interesting and puzzling, the more so when one reads that a check sample of 174 similar dwellings where no sink heaters had been fitted showed an equal number of increases and decreases. For what it is worth, I would mention that following an intensive sink water heater campaign in one division of my Board's area 500 sink heaters were sold which, on an annual basis, give an average increase of approximately 17 therms. It would be very interesting to hear about the experience of other boards in this matter.

Surprised

'In this section of the paper reference is made to stiff competition from the immersion heater. I am surprised that no mention is made of the gas attachment for the back boiler of a solid fuel grate for summer water heating. I should like to ask the author to give us his experience in the Eastern Division of this appliance, together with his assessment of "added therms" brought about by its installation.

'No specific mention appears to have been made in the paper as to the desirability and possibilities of increasing the sales per consumer by the development of new, or at any rate new in this country, appliances such as forced convection dryers, incinerators and dishwashers. Drying, which can be a potential load of some substance, is dismissed in a short paragraph. I would not agree that the limited space in the kitchen has stiffled the development of gas dryers in the home. I would suggest that the inexplicable apparent lack of enthusiasm for this load on the part of the industry and the manufacturers has resulted in nothing being produced to stifle. For some years now there has been on the market a natural convection gas dryer, but I would wager that the sales of this appliance have been very small while in the same period the electrical manufacturers who have come into the field in the last year or so have a number of natural convection models on the market. They do not appear to have been stifled by the space limitation although exactly the same limitations apply to them. Incidentally, the numbers that are available give an indication of the potential market.

Most Important

'The author refers to the effects of the enthusiasm of the staff in sales campaigns. In my opinion this is the most important factor of all, transcending all the technical aids of selling, important though they be, such as publicity, showrooms, market research, and so on. I should like to ask the author for his comments on the individual commission scheme as against the group commission scheme.

Mr. J. D. C. Woodall (South Eastern Gas Board) referred to it as a 'splendid paper' and mentioned in detail 'the one point where I feel that the author has gone off the rails—tariffs.

'On p. 9 of the paper the author says that space heating is one of the most effective ways of securing an immediate increase in domestic gas consumption.

Left to right: Mr. W. Foster, Mr. J. B. Clay, and Mr. R. Gillespie.

He goes on to say, "Increased gas sales should enable more promotional tariffs to be offered, and improved sales of appliances should also encourage development by manufacturers and contribute towards a reduction in appliance prices . . . ." I think that is entirely the wrong way round. The first thing you have to do is to introduce a promotional tariff and then you will sell more gas, and the only certain way to reduce the price of gas is to sell more of it.

Cashing In

'Dr. Burns told us, in his Presidential Address, of the wonderful new methods of making gas. On the sales side, if we can sell more gas I think that the gas engineer is perfectly capable of making it in new plants at a price lower than it can be made in conventional plants. Therefore every gas board should introduce a competitive gas tariff now to cash in on the splendid work of the engineers'.

Mr. Woodall said the author reminded him of the dealers' conference which the North Thames Gas Board held recently and to which he was invited. 'It was a most impressive conference and it was well written up in the Technical Press. I endorse everything which was said about it and we in the South Eastern Gas Board are looking very much more seriously at this business of appointing authorised dealers. It is easier for the North Thames Gas Board in their very built-up area where there are large numbers of shops and where their showrooms do not cover the area as they do in the more rural areas of the country. In London the gas showrooms are thin on the ground in relation to population and there is a case for dealers.

'One of the things which I cannot understand is why more people do not set up as authorised dealers for a gas board, confining their activities only to selling gas appliances. If any of you are dissatisfied with your salaries I would suggest that you rent a small shop and set up as salesmen of gas appliances. The gas board will stock all the appliances for you and will handle all the paper work, and all you have to do is to be charming to the consumers and the money simply rolls in! There is a dealer in the South Eastern Gas Board's area who does just that. He looks after one shop and his wife looks after another and between them they do very well indeed.'

Load Variation

The **President** referred briefly to the remark made by Mr. Phillips on the question of peak load. Mr. Phillips had mentioned a paper, written four years ago, on the effect of load variation on costs. 'What that paper did was to seek to analyse the costs of the various loads which the gas industry has got to meet. It has an importance now and a continuing and increasing importance because one of the big future potential markets for gas is for space heating, and it is as well to know what the effect of space heating is on costs.

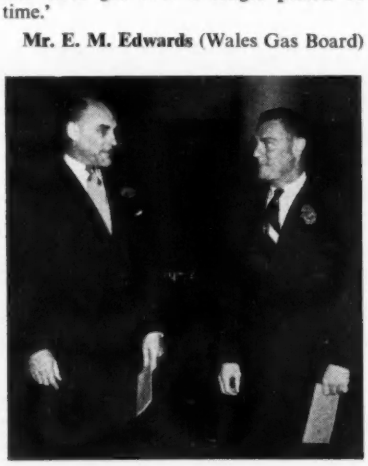
Inspecting the Romford works.

'Several things came out clearly in that paper. One was that the amount of peak load is relatively small. Secondly, it appeared also that that peak load is an extremely expensive load to manufacture but by virtue of the fact that it is so small those high costs are spread over all the gas and the total effect is not very great. It also pointed to another very important moral indeed, and that is that the peak load should be spread over a longer period of time. The salesmen should direct their efforts to selling that peak load right through the winter. It should start in October and continue until May, and then the superimposed effect of an additional gas peak load on that is very small indeed. That is where the space heating load should be sold so that it has an optimum effect on costs. I thought it worth mentioning that at this stage.

Maximum Demand

'We should remember, too, the way in which the electricity people handle peak load. They put in a maximum demand meter, although I would not say that that is necessarily a good way for the gas industry. The better way is to sell more gas over a longer period of time.'

Mr. E. M. Edwards (Wales Gas Board)



Mr. D. P. Welman, Chairman of the N.W.G.B., chatting with Mr. Peter Paul, Texaco Development Corporation of America.

said this was a paper dear to his heart, and he had been cheered to hear one speaker refer to a domestic load of 350 to 400 therms per annum. He thought that was rather too low!

'There is one point upon which I should like to have the author's views. How do we do our selling? There is no reference in the paper to the actual use made of district salesmen. I think that many of us will say from experience that all avenues of sales development must be exploited. The most effective selling is done in the customer's home and it is a comparatively easy matter, if you have sufficient trained salesmen, to flood your distribution department with business in such a way that it cannot cope with it. So far as trained district salesmen are concerned, how many of them per 10,000 consumers does the author feel is a reasonable figure, bearing in mind the cost of selling? That really is the first and most important point.

More Expensive

'The second point is a matter of policy. Reference has been made to the fact that the higher efficiency appliances are naturally more expensive and the question that comes to mind is this. If we want to sell an appliance of greater efficiency which will encourage our customers to use more gas, what is the author's view upon the present practice of applying the same percentage of overheads to a higher priced appliance as to a lower priced applance, bearing in mind that the costs are more related to the handling and installation of the appliance than to the details of the design of the appliances? I do not know whether I have made the point clear but whether an appliance costs £10 or £20 the costs of handling it and installing it are not so very different. I would be interested to hear the author's view on that particular point. Is it desirable to scale down the overheads if we want to sell a better and more efficient appliance?'

It was announced that the author would reply in writing.

UTILISATION EFFICIENCY of INDUSTRIAL GAS APPLIANCES

by E. A. K. PATRICK,
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IT is a safe assumption that, in relation to heating systems, use of the word 'efficiency' will normally be taken to relate to 'thermal efficiency.' The effectiveness with which heat supplied to a system is employed is, indeed, of great importance, especially to an industry devoted to selling heat.

The definition of thermal efficiency that will come most readily to mind is:—

$$\eta = \frac{\text{Heat transferred to work}}{\text{Heat of combustion of fuel used}}$$

The numerator of this expression will call for considerable discussion. The denominator contains the calorific value of the fuel, and if, as in the case of town gas, this contains free or combined hydrogen, two values, known as the gross and net value respectively, can be defined.

Gross Value

It is general practice in this country to use the gross value, one practical motive being that the price of fuel, where sold on a thermal basis, is linked with its gross calorific value. There is, however, an opposing school of thought.

The principal point made is that in many instances the nature of the duty to be carried out makes it impossible for condensation to be obtained or permitted, and so it is impossible for the designer to attain 100% efficiency. It is said, therefore, that the quoting of efficiencies based on gross calorific value is unfair to the designer and misleading to the user. There is considerable substance in this argument, and it is particularly relevant from a design (as opposed to an economic) point of view when systems employing different fuels are being compared.

The difficulty is, however, that universal adoption of this definition would in some cases result in thermal efficiencies exceeding 100%, and this is generally felt to be undesirably confusing.

We can now turn to a consideration of the numerator of our expression, and start with the domestic kettle. Here is a case where the definition is easy to interpret. Heat into the work is simply the product of the weight of water heated and its temperature rise. This, divided by the gross calorific value of the fuel burned gives a direct measure of how well the set task (heating water) has been done.

A domestic kettle used on a gas hotplate has a thermal efficiency of 29 to 46%, with an extra 5 to 10% for a finned-base kettle.

The instantaneous water heater gives an efficiency, when working at its rated output under equilibrium conditions, somewhat in excess of 70%. It has, however, been found that, if 2 pints of water are drawn from a multi-point water heater, the thermal efficiency measured according to our definition, is some 18 to 20%. This is an extreme case, but serves to bring out the very considerable effect that the pattern of use can have on efficiency. Even an instantaneous sink heater has an efficiency of only 35 to 45% if 2 pints of water are drawn, which does not compare particularly well with the kettle.

The sole purpose of introducing this example at this stage is to make it clear that there is no unique definition of thermal efficiency appropriate for all occasions and fully descriptive of the performance of a system.

Though efficiency has no absolute value, it is a useful tool in comparing performances of various systems, its exact definition varying as required. The important step is the realisation that most, if not all, heat-using appliances have more than one thermal efficiency.

A convenient way of breaking down this problem is to imagine that the appliance design is the joint work of two men. One, who may be called the 'process designer,' dictates the form and construction of the part of the appliance that has to be heated, the other, called the 'combustion designer,' is responsible for liberating the required amount of heat and securing its passage into the appliance. Once there, its fate is not his concern, but that of his colleague.

In a fuel-burning appliance, there is always a bounded combustion space. Heat is released within this space and transferred across a boundary, which may be solid, liquid, or gaseous, and may consist of all, or only a part, of the envelope of the combustion space. The combustion designer has to arrange for this, accepting any limitations of area, shape and temperature laid down by the process designer. The thermal efficiency with which he manages to do this is an important feature of the overall design, and will be called the 'primary efficiency.'

The process designer may be obliged, by circumstances beyond his control, to waste much of the heat he has been given; he may even 'waste' all of it, if we stick to our original narrow definition of efficiency. The final amount of heat arriving in the work being heated gives rise to an 'overall thermal efficiency.'

An excellent example of the usefulness of this idea lies in the design of immersion-tube-heated vessels. Considerable work has been done in evaluating the efficiency of the liquid-backed gas-fired immersion tube, and from this work it will, it is hoped, be possible to

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predict the primary efficiency with some certainty. Once the heat has passed through the wall of the tube, however, varying fates may await it.

The tank may be a bulk water heater, in which case the only losses are those by radiation and convection, and by evaporation from the liquid surface. If the tank is well lagged, and has a lid, or is provided with floating insulation, these will be minimised.

But what if the process involves holding the contents at 180°F. all day for the purpose of immersing metal castings in it for degreasing? An unlagged and uncovered tank will use appreciably more gas than a similar tank well lagged and provided with a lid. This waste of fuel is the fault of the process designer, and the combustion designer, who may have done an excellent job, cannot be blamed for the poor overall performance.

The process designer has other pitfalls he must avoid, such as the provision of too large an appliance, which will have excessive surface heat losses, etc., and, if intermittently used, too much heat capacity. The over-large appliance may not be worked to its full capacity, thereby incurring excessive stand-by losses.

Multiple Efficiencies

If the reader has now been persuaded that an appliance can have two different thermal efficiencies, he will, perhaps, fairly easily believe that, in some cases, three or more efficiencies can be defined. A good example of this is a water still. Stills consume fuel in order to convert cold feed water into cold distilled water. An overall view of this process produces a thermal efficiency of nil. This, of course, does not help to distinguish between a good still and a bad still, for which purpose some parameter, such as pounds of water distilled per therm of fuel consumed immediately suggests itself.

If we examine more closely the operation of a conventional still, two salient points emerge:—

(*a*) Heat wasted from an appliance after its provision has been attended by losses has a proportionately greater effect on thermal efficiency. Any heat saving at such a point carries with it a proportion of the losses that have preceded it.

In the case of the still considered, a saving of 13% of the steam generated will also give rise to a saving of 13% of the flue loss and of the combustion chamber surface loss (assuming the reduction in gas rate does not materially alter the steam generation efficiency).

(*b*) Process efficiency (quality of the product) conflicts with thermal efficiency and fuel economy; reduction in the reflux ratio will probably give a lower-quality distilled water.

In generating 1 lb. of steam from cold water, some 1,150 B.t.u. have to be supplied, of which 970 B.t.u. are latent heat of evaporation. Each 1 lb. of steam, therefore, passing to the condenser of the still, will give up at least 970 B.t.u. to the condenser water. This would be sufficient to evaporate 1 lb. of condenser water, if it were already at boiling-point. If this were done, another 1 lb. of steam, and eventually of distilled water, would result, and this in turn could evaporate a third 1 lb. of water, and so on.

The real limitations to this system are provided not by the first, but by the second, law of thermodynamics, which demands that some driving force, in the shape of a temperature gradient, must exist if the heat transfer is to take place at a finite rate. This can only be provided by arranging a gradual fall in steam pressure in the various stages, and as a result the condensate give up less heat per lb. in each successive stage. The practical limit is governed by the range of working pressures. There is a practical upper limit to the pressure at which the first stage can be worked, and also a practical limit to the vacuum that can be maintained in the last stage.

This type of system is known as 'multiple-effect evaporation' and is used in industry for evaporating many solutions, as well as for the provision of distilled water. There are a number of complicating factors which limit severely the number of stages, or 'effects,' and three or four effects are usually regarded as the maximum.

One well-known limitation in the attainment of high thermal efficiencies in fuel-fired equipment is that the products of combustion must leave the working space at a temperature above the working temperature. As a result, there is a reduction in the attainable thermal efficiency as the working temperature increases.

High-grade Heat

Another way of looking at this is to say that heat has quality as well as quantity, and references are frequently made to high-grade or low-grade heat. High-grade heat (that is, heat available at a high temperature) can always be degraded into low-grade heat, but the reverse is impossible. This, in scientific terms, means that we are now considering the second law of thermodynamics.

The simple idea of energy quality can be applied by calculating the fraction available at a given temperature. In a system where heat is transferred from a hot gas to work at a lower temperature, the fraction of the energy contained in the hot gas that is available to heat the work is:—

$$\frac{T_M - T_A}{T_M - T_O}$$

where T_M is the absolute temperature of the mass concerned.
T_A is the absolute temperature of the work.
T_O is the absolute temperature of the surroundings.

This fraction may be plotted against T_A as a percentage. Departure of the curve from a straight line is due to changes in specific heat and to dissociation at high temperatures. Such a diagram shows, for example, that only 40% of the energy in the products of combustion of town gas with theoretical air is available above 1,400°C. This gives an absolute upper limit, therefore, for the thermal efficiency of heat transfer to a body at 1,400°C. in a simple furnace. In practice, of course, some excess of air will almost certainly be present, and all heat losses have to be replaced at the working temperature, so that thermal efficiency of, say, 20%, would be quite creditable.

Maximum

A suggestion that obviously arises at this stage is that thermal efficiencies should be related to the maximum attainable at the working temperature, rather than to 60°F. as is implicit in the use of standard calorific values.

Thus we have a new definition for high temperature work:—

$$n = \frac{\text{Heat transferred to work}}{\text{Heat available above working temperature.}}$$

This, it is suggested, is a fair measure of the efficiency of the furnace itself, though the original definition employing standard calorific value as the denominator is still valid so far as the overall employment of energy is concerned.

This fall in attainable efficiency as the working temperature rises is accompanied by a further unfortunate effect, namely, that the available temperature gradient between the hot gases and the work, which is the driving force for heat transfer, also diminishes seriously. The result of this is the slowing down of the rate of heating, with a consequent increase in heat lost and so of fuel consumption.

The only approach to increasing the efficiencies attainable in high-temperature processes is to increase the amount of energy available a high temperatures. This, in effect, means that the flame temperature must be increased, and two ways by which this can be done offer themselves—(i) by preheating the combustion air and, if possible, the fuel; and (ii) by the use of oxygen enrichment of the combustion air, and if processes at really high temperatures, above, say, 2,000°C., are considered, dissociation effects may reduce the beneficial effect of oxygen enrichment or preheat.

With regard to the use of preheated air or fuel, the most obvious and usual source of this heat is that contained in the waste gases. The recovery of waste heat by the use of recuperators or regenerators to preheat combustion air and, in certain cases, fuel gases, is an established practice. In some industries, notably the ceramic industries, recovery of heat from the stock, and preheating of the stock are employed as a means to reduce fuel consumption.

Another form of waste-heat recovery consists in the return of the hot waste gases themselves to the heating system. Thus hot gases are recirculated through the system, and the heat given up to the work is replaced by the addition of a small volume of very hot gas; a corre-

sponding amount of the outlet gas is discharged in order to maintain constant pressure.

Such a system has many advantages. A greater mass of hot gases passes over the work, thus increasing the rate of heat transfer, and also reducing the temperature difference between the inlet and outlet of the appliance. From the present point of view, however, the great advantage is that only a relatively small amount of heat below the working temperature is thrown away and only a relatively small amount of high-grade heat is supplied.

Perhaps the final proof, if it is needed, that thermal efficiency is a criterion of limited value, is the case where it is necessary to hold work at a fixed temperature for a period of time. In such a case, the heat transferred to the work is zero, and thermal efficiency by any conventional definition must also be zero. Nevertheless, one furnace may still carry out this process with the consumption of half the fuel required by another furnace, and be, therefore, twice as 'efficient.' It is possible, however, to measure this efficiency in terms only of fuel used per unit weight treated (e.g., therms per ton or B.t.u. per lb.).

The lesson to be learned is that different thermal efficiencies can be defined and used for the quantitative assessment of various features of a heating apparatus, each definition being appropriate for its own individual purpose, but probably meaningless and possibly misleading if applied for other purposes or used by those who are unaware of the original definition. Such efficiencies are, in general, principally of use to those concerned in the design of the appliance, and to those who wish to compare differing processes.

From the users' point of view, however, the final judgment on the appliance as a whole must in the end be made by reference to the output per unit of fuel consumed. Therms per ton of product treated, or B.t.u. per lb. of product treated, is the yardstick by which, other things being equal, the appliance is chosen, and which measures the ability of the appliance to play its part in conserving the nation's fuel supplies.

Unfortunately, this simple picture is disturbed by other considerations when the production engineer has to make a choice of plant. There are a number of considerations that may cause the selection of plant and methods that use more than the minimum quantity of fuel.

It cannot be too strongly stressed that the plant that will in the end be chosen and used is the one that will give the lowest overall production cost, and in this connection there is a wealth of meaning in the word 'overall.'

Significance of Waste

Every industrial gas engineer will be able to think of many instances where an improvement in product quality justifies the use of either of more fuel or of a more expensive fuel. A point to be remembered is that the significance of waste increases as work passes through a factory. Thus, a spoilt casting can usually be melted down, the only waste being the fuel used in the remelting plus any cost for the new mould. Once, however, further processes have been carried out, a considerable sum, in the form of labour, may be invested in the work-piece. A heavy responsibility, therefore, falls on the designer of plant for a heating process carried out toward the end of a series of manufacturing processes. The heat treatment of gears, and particularly of large broaches, comes to mind in this connection. It is safe to say that almost any amount of extra fuel would willingly be burned in an effort to save one such broach once the labour and skill devoted to its manufacture have been invested in it.

In most processes labour is a much more expensive item than fuel, and in consequence fuel costs are a relatively small fraction of total production cost in many industries. Figures have been published showing that, for example, in general engineering and in the motor manufacturing industries, fuel costs are 2.3 and 1.4% respectively of the production cost.

This fact has a direct effect in that managements are usually far less concerned about fuel economy than they are about saving labour. Thus, an inefficient plant that will heat up quickly on a Monday morning may well be a better proposition than a plant designed for efficient steady output, but which takes several hours to heat up.

There are also less obvious effects of the scarcity of labour: For instance, a case is known where a large firm proposed to change from gas to electricity for a heating process, notwithstanding the fact that electrical equipment would be appreciably more expensive in both capital and running cost. The reason given was simply that electric appliances would be quieter and give cooler working conditions, and thus enable them to retain their workers and so maintain output.

Another instance may be quoted where a change in type of furnace was worth while simply because of reduced heat loss with the result that pieceworkers were able to maintain their output all day, whereas previously on hot days they were worn out by mid-afternoon.

Another somewhat intangible matter is the annual cost of the space occupied by equipment. This is of varying importance, but particularly in heavily built up areas such as central London, space is at a great premium.

Industrial gas practice can be relied upon to provide examples of virtually any pitfalls that awaits the unwary combustion engineer. Thermal efficiency is a very useful quantitative measure of performance, providing the user recognises its limitations, the principal one, perhaps, being that it is unwise to use it for high-temperature applications, particularly when dealing with a lay public. The author tries, in his own work, never to use the expression 'thermal efficiency' for any process that gets red hot—that is, above approximately 500°C.

Thermal efficiency is the concern of the design engineer; fuel efficiency is, in present-day circumstances, the concern of the Nation, but industry is necessarily concerned with overall production efficiency. That these interests are sometimes incompatible is not a new thought, but the need to deal with this point explains why this paper does not bear the title 'Thermal Efficiency,' as was at first intended. The industrial gas engineer is directly concerned with all three aspects of efficiency; it is his ability to promote the third type that will do most to secure the industrial loads of the future.

COMM. No. 527

DISCUSSION

Mr. E. H. Hubbard (Flame Research Station): 'There are two interesting aspects of the paper on which I should like to comment. The first is this question of high temperature efficiency. The trouble is that most of the data which has been collected on heat transfer from flames have been obtained with instruments which are themselves relatively cold compared with the flame. It is not easy to have a thermal bar permanently maintained at 1,550°C. For example, the radiant energy measured from an industrial luminous flame is at least five times greater than that measured from a similar non-luminous flame, assuming that all the other conditions are maintained constant. In applying this result in practice we have to be careful to see that we are not applying the result in the wrong instance. The result is only directly applicable in cases where the work to be heated is itself cold, as in the case of a boiler or a steel furnace full of cold metal.

'If the luminous flame has a temperature of 1,550°C., which is a reasonable figure without preheat, its non-luminous counterpart will be some 150° to 200°C. higher, simply because it has not released so much of its energy. As the temperature of the work rises, the advantage of the luminous flame decreases until, in the example quoted here, when the work is about 1,300°C. the heat received by radiation only from the two flames is the same. Obviously when the work itself is at 1,600°C., as is the case of a steel bath during refining conditions, the flame at 1,550°C. is useless.

'The author has introduced this conception of high temperature efficiency and ne has qualified it, and I would emphasise that by saying that it is really the combustion chamber efficiency. If we take one of the two flames I have mentioned and use preheated air or oxygen enrichment we shall certainly increase the flame temperature and the heat transferred to the work by radiation only, and we shall increase the

possibilities of transferring heat by convection. We shall certainly increase the simple thermal efficiency of the whole plant, but we might not increase the high temperature efficiency.

'The second point refers to the first conclusion which the author gives in Section III(D) of the paper. He states "heat wasted from an appliance after its provision has been attended by losses, has a proportionately greater effect on thermal efficiency." Here we are not dealing with flame and combustion but with what goes on in the low grade heat end of the system. To quote an example of this we might think of our popular launderettes with ten or 15 washing machines using vast quantities of hot water. If the simple thermal efficiency of the hot water provision at the inlet to the washing machine is only 50% it may be possible to save much more fuel by fitting a heat exchanger so that the cold feed water can be heated by the hot waste. That may be better than attempting to increase the efficiency of the boiler system and storing the hot water.

'What are the practical applications of the paper so far as industrial gas engineers are concerned? There the author has stolen my thunder, but I would emphasise what he has said, namely, that we should be able to calculate the simple thermal efficiency for each section of our customers' processes.

This may be difficult and may require the collaboration of the customer. So much the better. Having done this we should be able to predict what will happen if we alter one of the sections, either because it suddenly goes wrong or because we design that particular section better. The question is how will it affect the section before and the section after and the thermal efficiency of the whole process? Of course, the customer is interested in economics and the author has given a beautiful example in the paper where the cost of the gas for the heat treatment was 6s. and the cost of the broach was £135. I do not think that that particular industrialist would mind if the cost of the gas was 12s.

Comparison

'The author's example of the common kettle has encouraged me to make a few simple calculations regarding efficiency of utilisation on the production of my morning cup of tea. I have compared three methods of boiling two pints of water. One is to fill the kettle from a cold tap, the second is to fill it with the first two pints produced from an instantaneous sink water heater, and the third is to discard the first two pints from the sink water heater and fill the kettle with the second two pints. It is possible to save 25% of the time taken to boil the kettle merely by using the first two pints from the water heater as compared with using water from the cold tap, and no more gas is used if it is assumed that the efficiencies are the same, which they are. On the other hand, if you allow the first two pints from the water heater to run to waste and use the second two pints 40% of the time can be saved and only 4% more gas is required. If your kettle happens to be an inefficient one you save even more time.

'If the paper encourages us to apply the author's principles in our every-day life in contact with the users of gas on a large scale it will have performed a great service.

Mr. W. Johnson (South Eastern Gas Board): 'The author has rendered us a useful service in drawing attention to the importance of utilisation efficiency. This is the best approach to selling gas, if not the only one, in those areas where the price of gas is high in relation to other fuels.

Constant Quality

'We are all familiar with the usual advantages claimed for gas. One is constant quality, although it is not constant enough in some processes. Another is saving of space. That is important in the crowded London area but is relatively unimportant in 95% of my Board's area. Another is comfort but we generally lose this argument to electricity. We come now to the life of the appliance, increased production, reduced wastage, improved product and so on. These are the usual types of advantages which we work on when we want to get load and provided that we can prove these virtues it makes it possible to justify the high cost of gas.

'The engineer needs to have a sound knowledge of the customer's processes and must be able to form some estimation of the economic value of fuel in relation to the other problems of production. I will give one example of this approach in connection with the galvanising process. The thermal efficiency of this process is low and consequently gas is in an unfavourable position in relation to oil or solid fuel. There is, however, one factor which causes considerable loss of material and heavy maintenance costs and that is corrosion of the galvanising baths. Two years is considered quite a good life. The attack of zinc on iron increases rapidly if the bath is heated a few degrees above dipping temperature, a condition difficult to avoid by the usual methods of heating.

'One of our largest customers was persuaded to adopt an indirect method of heating, using lead to heat the bath and the lead was itself heated by gas immersion heaters. This process has been in use for ten years and the galvanising baths have given a life of ten years with negligible iron-zinc corrosion. In spite of the indirect method of heating we were pleased to find that the thermal efficiency was relatively high compared with any other fuel and our customer is satisfied that the net result is that gas gives the best production efficiency.

'Projects such as the one I have described need a staff of skilled engineers and a well equipped projects laboratory in order to be able to carry out practical experiments and finally to design, make and install the plant. I do not think that the needs of our consumers can be met in any other way. The industrial sales engineer must have such backing if he is to be well received by the industrialist. As an industry I do not think we are devoting enough skill and energy to the task of developing methods and designs for using gas at higher production efficiency. The main difficulty is to find staff with the skill and experience but I would ask whether we are doing enough to recruit and train suitable engineers. There should be a projects laboratory in every board, properly controlled and staffed by men who have the knowledge, time and ability to solve problems. Some boards, including my own, have such facilities but I do not know any which are not capable of profitable extension if the right people can be trained.

'Finally, a projects laboratory does not mean that you do not need the services of the industrial appliance makers. It is, or should be, an opportunity for greater co-operation, particularly with the makers of machines such as steel moulding machines which use heat in some minor form.'

Mr. E. E. Blandon (De La Rue & Co., Ltd.): 'I should like to comment on one particular remark which was made during the discussion. Mention was made of launderettes and it was suggested that the efficiency of the hot water provision for them might be as low as 50%. That seems to me to be lower than it should be. There are just over 1,000 launderettes in this country and 700 of them have hot water equipment worked by gas and they are, of course, working at a good efficiency which should make the overall efficiency not far below the efficiency of the gas operated hot water systems. Furthermore, there is available to them as part of the standard equipment a heat exchanger which in fact they often do use.

'I think perhaps a certain amount of the argument in the paper about efficiency might have been made a little clearer if the original wording of the definition had been slightly different. The author defines thermal efficiency as "heat transferred to work" over "heat of combustion of fuel used" and that clouds the picture a little. The more usual definition brings in the term "useful heat" and I think that that goes a long way towards putting the whole thing in perspective. If in a clear and measurable way you are using heat then that definition of thermal efficiency gives you a good measure of what you want, but if what you are using is not heat but temperature, and more particularly if the time factor comes in as well, then all the complications of thermal efficiency do come in.

Impossible

'With regard to the use of gross or net calorific value, I was very pleased to see this point mentioned in the paper at all because from the point of view of the appliance designer it is rather hard to design an appliance with an efficiency

of 90% and then to find that the transfer of the available heat is only 70%. I was a little sorry to see 100% efficiency dismissed as impossible. Another consideration which will perhaps have some weight is that working on gross value does count against the gas industry because the 10% difference between gross and net value is just about the biggest on any of the ordinary fuels available so that the difference between the efficiencies on the two bases is greater with town gas than with anything else. The other point is how this ties up with this proposed definition of high temperature efficiency because obviously, if you are going to load that with the 10% which remains constant all the way through, it will make a tremendous difference when it comes to the higher temperature.'

Mr. H. A. Haines (N.I.F.E.S.): 'The author will have done a good service to us all if he succeeds in laying the bogey of "efficiency." Never has so simple a word meant so little to so many for so long and because it is always quoted as a percentage the confusion is greater. Technologists find little difficulty in dealing with these matters, but in our daily work we are called upon to discuss technical reports resulting from detailed tests on boiler plants and a wide range of process plants. These discussions usually take place with the managerial side of industry and I am not at all surprised that they find it difficult to follow our reasoning.

Complete Confusion

'A few simple examples may make my point clear. Say that a boiler operates at 60% efficiency. If this is raised to 75% efficiency the difference is 15%. For equal output, however, the fuel consumption will be reduced by 20%. This foxes most consumers completely until it is explained that 100 at 60% equals 60, 80 at 75% equals 60 and that the decrease of 20 over 100 equals 20%. When the result is a percentage of a percentage the confusion is complete!

'In the case of a boiler house efficiency of 70% and a process efficiency of 20% the overall efficiency is 14%. If the boiler house efficiency is raised to 75% and the process efficiency remains at 20% the overall efficiency will be 15%. If the boiler house efficiency is 50% and the process efficiency is raised to 30% the overall efficiency is again 15%. Therefore, in this particular example a 5% increase in boiler house efficiency gives a 1% increase in overall efficiency and a 5% increase in the process efficiency gives a 3.5% increase in overall efficiency. It is also interesting to note that the boiler house efficiency could be lowered by 20% and the overall efficiency maintained at 15% if the process efficiency could be raised by 10%. In other words, if you drop the boiler house efficiency to 50% and raise the process efficiency by 10% you get the same overall efficiency as you do with a boiler house efficiency of 75% and a process efficiency of 20%.

'In our work we find that whilst considerable attention has been given to increasing the efficiency of steam raising plant, little has been paid to efficient steam utilisation. During the last few years we have concentrated on this aspect with truly staggering results. Much has been accomplished by the training of boiler operators and much more will be achieved when management realises that operatives using steam also need some elementary technical training.

'When one discusses fuel efficiency with management, one cannot blame them if they show little interest. They are, after all, concerned with two things only, how they can cut down their fuel and power costs, and how they can increase productivity without heavy capital outlay. In fact they are more concerned with the latter because the fuel costs in many industries are only about 30% of the total cost of production. It is, however, almost axiomatic that if you practise fuel efficiency you practically always get higher productivity. This is especially so in regard to better steam usage.

'Because of this, it is sometimes difficult to assess the fuel savings resulting from an efficiency survey. Very often the fuel consumed is equal or even greater than before, but the productivity has increased substantially. When assessing running costs for alternative methods of heating, it is not sufficient to compare the costs of various fuels coupled with their respective heating values and combustion efficiency in order to evaluate the running costs. This may be justified provided the amount of heat delivered to the heating system remains constant for all fuels.

'This is rarely the case. For instance, if a hand fired solid fuel boiler is converted to automatic firing by liquid or gaseous fuel, it will maintain the temperature of the building or the comfort conditions called for by the thermostatic controls. This can rarely be achieved by the slower response of the hand fired boiler and the net result can well be that a considerably greater amount of heat is put into the building than was the case before, with consequent increased heating costs. In such a case the consumer is alarmed at the cost and is inclined to believe that he has been misled. In point of fact the combustion engineer claims that he has increased the efficiency of the plant. The occupants say that the plant is more efficient because they are far more comfortable. The manager, however, says that the plant is less efficient because his heating costs have increased.

Common Fault

'I was interested in the author's figures for the travelling bread baking oven showing the bad effect of part loading. This is a common fault in all types of apparatus and is one of the prime causes of fuel wastage. The no load losses on most machines and heat consuming process plants are much higher than most people realise and increase of load factor is the simplest method of increasing efficiency. Lyle once ran one of his factories at no load for several hours and reached the staggering conclusion that the no load losses were four-fifths of the full load.

'The author has made certain remarks on fuel efficiency on p. 20 of the paper. He says there that different thermal efficiencies can be defined and used for the quantitative assessment of various features of a heating apparatus and that such efficiencies are in general of use to those concerned in the design of the appliance. He adds that each definition must be appropriate for its own individual purpose because otherwise it may possibly be misleading. I thoroughly agree with the statement that in considering efficiencies we must use therms per ton and heat used per pound as a yardstick and forget all about percentages, particularly when discussing what an apparatus will do and cost. Those words are words of wisdom and therefore I use the author's words and not my own.'

Mr. R. F. Hayman (Gas Council): 'Listening to this discussion it seems to me that very little stress has been laid on this problem of good or bad design. The author has referred to the bad effects of over-designing. Gas is very easy to use and that is both our strength and our weakness. No one will deny that the advantages of being able to turn down the kettle and the cooker have helped us to sell more gas but in industry we have to get away from burners and, indeed, we have to design combustion chambers with complete heat surface systems. More and more in industry the gas section of an apparatus has to fulfil a function. I do not know what the author would call a function but let us assume that it means that the gas section performance must be as good as the overall performance of the rest of the plant. It may have to work often for long periods without attention, or fully or partly automatically, and no single criterion must be sacrificed to the overall requirements.

Superior

'It is in the end the consumer who wants to know the answer in terms of the cost of fuel per article produced or per unit of production. I think that that expression can be applied to almost anything in the industrial, commercial and domestic fields. I should like to see that expression used more commonly.'

Mr. A. Higgs said: I venture to cross swords with the author on the inference drawn in the second paragraph of his conclusion on p. 23 of the paper that perhaps it is to our disadvantage to discuss the thermal efficiencies of town gas in high temperature application. In this connection it has been my experience that the thermal efficiency obtainable in gas fuel plant for high temperature work is substantially superior to that obtainable with competitive fuels and that in developing a case for new business the comparative thermal efficiency is always a very important factor in the negotiations. Indeed, in a recent instance we obtained a load of 120 mill. cu.ft. per annum on our assessment, in the negotiation stage, of the increased thermal efficiency obtainable with town gas compared with pro-

A pre-visit shot outside the Festival Hall.

ducer gas. We estimated that 35 therms of town gas would do the same job as 47 therms of producer gas. In practice we are doing the job on 31 therms, so we had a margin in our favour even then.

'The reasons are well known. They are the removal of the semi-muffle requisite with producer gas, the reduced flue line and higher flame temperature with better control of air/gas rates with town gas, all of which contribute towards greater efficiency. The comparative thermal efficiency of properly designed gas furnaces for forging at 1,250°C. is obtaining substantial load for us against fuel oil. Reiterating the point made I do not see any reason for being reticent about the comparative thermal efficiency because essentially in all negotiations it is one of our strongest talking points.

Paved the Way

'In this case in point we constructed a prototype with correct combustion chamber size, which is smaller than for fuel oil, and we were able again to offer 9d. an hour on each of the small furnaces, so that in the negotiation stage it was our assessment of comparative thermal efficiency which paved the way for the installation. I feel that the value of the paper would have been enhanced if the author had included a section dealing with the comparative thermal efficiency of town gas as against competitive fuels.'

Mr. A. C. Jennings said the author had mentioned briefly what was the most important point about utilisation efficiency—what an appliance would do on firing, as distinct from what it was designed to do. 'The important thing is what it actually does on the factory floor. I think that we shall only get an efficient appliance when we have sent our engineers into the factory to assess what the margin is and they have come back and tried to reproduce the working conditions in the laboratory. The design of an appliance on the drawing board is a very different thing from that same appliance working on the factory floor and my reason for speaking was to support what Mr. Johnson said about giving the district representative and the industrial engineer an opportunity to experiment in a projects laboratory. It is only when you have had an opportunity of working in such a laboratory that you really appreciate its importance and see the opportunities which it gives for training the engineers who are going into the factories afterwards. Therefore I strongly support Mr. Johnson's plea for development laboratories in area boards.'

Mr. A. H. Bird (Eastern Gas Board) said that in spite of Mr. Haines's presence he suggested that it was still permissible to underline the need for ensuring that good and efficient appliances, once installed, were, in fact, in good adjustment. 'While keeping a critical eye on thermal efficiency, or on inherent thermal efficiency of appliances, we who are selling and installing them ought to be able to take that for granted. I use the term "inherent efficiency" because we all know that there are appliances which are good but which nevertheless have shown a poor fuel efficiency and an overall efficiency below par.

'The author, by not mentioning the vital need for putting in and keeping appliances in correct adjustment, may be paying us a silent compliment, but we who visit our customers' factories and have to sell our fuel must be ever vigilant to ensure that the insidious leakage of efficiency through maladjustment does not occur. I am not thinking so much of the multiplicity of relatively small appliances in large and well conducted factories, where the management will call someone in, but in some areas it is very well known that the majority of the load is accounted for by the smaller consumer.

Optimum Efficiency

'With regard to overall efficiency, we should not assume, if indeed any of us do, that because a manufacturer is very watchful of his production costs he is necessarily ensuring the optimum operational efficiency of his gas appliances. He or his staff may not in fact know how to achieve it. For example, one sometimes finds a sizeable furnace which is kept at full working temperature at the week-ends simply because no one knows how low the temperature can safely be dropped without damage to the refractories. We have all seen a great deal of wastage from wash-off tanks because the users do not know how much can be saved by a simple lid or floating insulation.

'As Mr. Hayman has remarked, we have talked about the flexibility, ease of control, cleanliness and other advantages of town gas over the years. In areas where the price of gas is relatively high we often can only sell our fuel because of those virtues. The point I would emphasise is that we must make sure that our customers do take advantage of the virtues of our fuel.

Not Wise

'I should like to comment on the reference to managements being far less concerned with the fuel cost component than labour cost in their overall manufacturing costs. Of course they are because it is usually much the smaller of the two but I would suggest that it is not wise to press the argument of small percentage too far. If the fuel bill is, say, £50,000 and it could be halved by substituting a cheaper fuel with practically the same performance, the manufacturer would naturally think his own pocket a better place for the £25,000 than the coffers of the gas board.'

Mr. E. A. K. Patrick, in reply, said: 'If the reply is intended to deal with contentious isues there will not be very much for me to say.

'Mr. Blandon wishes to put the word "useful" into the definition of thermal efficiency. I have not thought about that very deeply but is that not what the paper is about? How many definitions can thermal efficiency be given?

'Mr. Higgs says that he is reluctant not to make use of thermal efficiencies in high temperature applications. My feeling is that there you are talking to someone who may not be really well up in the subject. If you talk to him about a 4% efficiency he will not think very much of you unless he is very well up in the subject. Mr. Higgs appears to have told his consumer that what will require 47 therms of producer gas will only require 35 therms of town gas, which is very much what the paper is advocating.

'I would only ask Mr. Hubbard if he sized his kettle to his one morning cup of tea!

'With regard to the question raised by Mr. Bird about furnaces idling at the week-end, I remember standing on the melting floor of a steel works watching the furnaces being loaded. There was present a senior member of the appropriate research association for that industry and he said to me 'You know, we can spend a lot of time improving the efficiency of one of these furnaces by 5% or 10% and the whole lot can be thrown away if, when the leader calls for scrap, there is none and he has to keep the furnace standing for 10 minutes.'

COMM. No. 529

95th A.G.M. — a 'GAS JOURNAL' Abstract

WORK STUDY:

Three Years' Progress at Edinburgh

THERE is a common misconception that substantial benefits can be derived from work study only where the operations are simple and continually repetitive, and that, therefore, the technique is one applicable for the most part to factory line production. This misconception has more than any other factor delayed the extension of work study into many fields. One object of this paper is to show that work study can be applied with great advantage to a wide range of operations within the gas industry.

The paper deals with applications of work study in the Edinburgh unit of the Scottish Gas Board in particular relation to:

(1) Ordinary meter reading and prepayment meter collection.
(2) Gasfitting and consumer service.
(3) Mainlaying.

Increases in productivity ranging from 25% to 102% have been obtained in these departments; labour costs have been reduced by from 15% up to 42%; operatives' earnings have been increased by up to 28%.

Work study is a critical approach to each and every activity with a view to obtaining the optimum use of the human and material resources available to an organisation for the accomplishment of the work upon which it is engaged. The opinion is frequently advanced that the questions relevant to such an investigation have always been posed by good managements and effective supervisors in the past, but this view is found, on close examination, to be at best true only to a limited extent, and in all too many cases entirely untrue. To obtain correct answers calls not only for an enquiring mind trained to investigate, but it also calls for the undivided attention of the enquirer.

What It Is

A wise beginning to the introduction of work study is an appreciation course attended by all levels of management and supervision concerned with the function it is proposed to investigate. At this, it must be demonstrated what work study is and what it can do, preferably by practical example. Above all, the highest level of management must establish complete confidence at lower levels that work study is being introduced to secure improvements in the future, and that the revelations of work study will not be used to criticise the conduct of affairs in the past. Unfortunately, the British workman often has an abhorrence of time study and work measurement. Nevertheless, work measurement can and does play an important rôle in a number of ways, and its objects can be grouped under the following heads:

(1) Basis for comparison of alternative methods.
(2) Correct initial manning of plant.
(3) Continuous economy of manpower.
(4) Effective planning of production and maintenance.
(5) Realistic labour costing.
(6) Basis for sound incentive schemes.

Only when the 'better way' has been synthesised by analysis of the existing method and by drawing upon the cumulative experience and ideas of all concerned in the operation, should detailed time study be undertaken.

Operatives should be educated to understand that a stop-watch, like a foot-rule, is just another measure to ensure that a task is efficiently carried out, and much can be done to dispel distrust by showing examples of the comparative times to carry out a simple operation by a number of different methods all seeming to the uncritical eye equally effective.

Where it is proposed to proceed to detailed time studies of the new method, payment of an incentive bonus is generally essential to the full acceptance and co-operation of the workpeople.

by

DAVID BEAVIS,
M.Inst.Gas E., A.M.I.Mech.E.,
GENERAL MANAGER,
EDINBURGH AND SOUTH EASTERN DIVISION,
SCOTTISH GAS BOARD.

Collaboration

Schemes now in operation in Edinburgh are so designed that workers of average ability enjoy a bonus of 25% above plain time rates. Much of the work carried out so far has been done in collaboration with independent management consultants, who although very expensive have proved to be invaluable, particularly in helping to train staffs in the new procedures. There is now a sufficiency of trained staff to co-ordinate, maintain and extend the applications of work study already in existence and to institute and direct further applications of method study and work measurement in new fields with, at most, occasional and decreasing assistance from external management consultants. This organisation is being developed at two levels:

(1) Divisional.
(2) Departmental.

The divisional organisation will have the prime function of co-ordinating all applications of work study throughout the division and of extending work study into new fields. The departmental organisation will have the responsibility for administering, maintaining and extending existing applications on a day-to-day basis. Much of the success obtainable as a result of work study will depend on the quality of supervision. A foreman or chargehand must, therefore, enjoy a reasonable reward for his responsibilities in relation to the operatives under his control. The question arises as to whether and, if so, to what extent the immediate supervisors should be included in incentive schemes. Opinion is still widely divided on this issue. A first responsibility of any supervisor is the quality of work being carried out, and, therefore, a direct relationship between productivity of operatives and supervisors' earnings is undesirable in that quality standards may be sacrificed

to attain higher productivity. On the other hand, much of the contribution that a supervisor can make to more effective working lies in preparation for the task, in ensuring that the correct materials and proper tools are provided at the right time, that the plant is available for maintenance, that all working drawings have been obtained, that the various skills are co-ordinated where several crafts are involved, and so forth. A solution is, therefore, sometimes sought in relating incentive payments to foremen to their success in avoiding idle time by operatives and other excess costs. Other formulæ relate supervisory reward to a combination of these two factors.

Meter Reading

The first major work study investigation in Edinburgh was carried out in the meter reading department, starting in January, 1955. Prior to this date, a simple, but crude, payment-by-results scheme related to past performance had been in operation. In the case of ordinary meters, this had been based simply upon the numbers of meters read in excess of a quota, without any especial regard for the varying amount of work involved in reading meters in widely differing districts. For prepayment meters, earnings were related solely to the amount of money collected and were not influenced by the numbers of meters emptied, nor was any provision made for varying proportions of silver or copper or for the consequences of successive increases in the price of gas. Further, the auxiliary meter readers and collectors, who were responsible for special readings and the follow-up of no-access calls, were remunerated at standard rates and could not participate in bonus earnings however conscientiously they applied themselves to their task.

The implementation of these rather crude methods led to inconsistencies which caused dissatisfaction to both management and operatives, and an intensive investigation was carried out by a small team, of existing methods and organisation, from which were prepared recommended changes. The team consisted of a resident consultant, two members of the Edinburgh staff, and an employees' representative.

The recommended new scheme was discussed with the operatives and their trade union representatives, and assent received to its operation for a trial period of one survey. The work of installing and nursing the scheme followed, and at the end of the trial period the scheme was finally accepted subject to extremely minor amendment in the light of experience.

It was found that the rate of working when actually engaged on meter reading and cash collection was satisfactory, but much time was wasted by daily journeys to the office to return completed work and receive fresh instructions. The advantages of carrying out this work on the district were soon apparent.

Under the former arrangements, the need for the cash collected to be checked and banked by early afternoon restricted the available collecting hours. To increase the effective collecting hours, arrangements were made for suitable strong-room accommodation for storing overnight cash collected in the latter part of the day. As in the case of the ordinary readers, work is now issued by the van drivers to eliminate the late afternoon visit to the office, so that the additional hours are fully utilised.

Time studies were made on the following operations.

(1) Walking between calls.
(2) Waiting at doors.
(3) Locating meters.
(4) Reading meters.
(5) Opening cash boxes.
(6) Counting cash.
(7) Clerical work (*e.g.*, writing prepayment vouchers).
(8) Changing meter settings.
(9) Paying cash into van.
(10) Collecting work from van.
(11) Visiting office. (Once per week.)
(12) Collecting keys. (Special appointments.)
(13) Travelling on public transport. (Special appointments.)
(14) Driving van.

Work values were thereafter established. The main variable in the case of ordinary meter reading was walking between calls, and it was found necessary to have separate values for two broad classifications of property. The lower value is used for flatted and terraced property, semi-detached houses and bungalow estates, and the higher value applies to factories, industrial premises, public buildings, large detached houses. For prepayment meters, the main variables were found to be the proportions of silver and copper collected. The values for prepayment meters were therefore divided into three parts:

(1) A value per meter read.
(2) A value per £1 of copper collected.
(3) A value per £1 of silver collected.

As a result of the study work, an acceptable percentage of 'no-access' returns was established, and provisions were made to modify bonus payments by 15% either way as an incentive to keep such returns at a minimum.

It was necessary to introduce a stabiliser to avoid undue fluctuations in earnings of auxiliary meter readers whose work is subject to many factors beyond their control. For a standard performance, the auxiliary reader, like the squad readers, receives 25% bonus. For performances above and below standard, the increase or decrease in bonus payment is, however, reduced by half, so that his earnings are cushioned against both abnormally favourable or unfavourable circumstances.

The results of applying a properly designed incentive scheme are summarised in Table 1.

Consumer Service

In providing a service on consumers' premises, overall productivity depends on two main factors:

(1) The proportion of working-time spent on these premises.
(2) The effective rate of working during that time.

It was soon established that the amount of time being spent on consumers' premises was being limited by:

(1) The necessity to report each morning to a central depôt for alloca-

TABLE 1.—*Meter Reading Department Comparison of District Performance Before and After Introduction of Revised Incentive Scheme Based on Detailed Work Study.*

	Number of Operatives			Meters Read or Emptied		Meters Read or Emptied per Man Week			Bonus Above Grade Rate		
	1954	1957	Change (per cent)	1954	1957	1954	1957	Change (per cent)	1954 (per cent)	1957 (per cent)	Change (per cent)
	1	2	3	4	5	6	7	8	9	10	11
Ordinary Readers :											
Direct	8·7	9·7	+11	259,217	323,239	610	680	+11	5	25	+20
Indirect	—	0·4	—	—	—	—	—	—	—	25	+25
Prepayment Collectors :											
Direct	19·5	15·4	−21	255,979	257,074	268	340	+27	24	33	+ 9
Indirect	2·0	1·9	− 5	—	—	—	—	—	24	33	+ 9
Motor Auxiliaries	3·0	4·1	+36	21,828	38,100	143	182	+27	—	28	+28
Foot Auxiliaries	7·0	6·8	− 3	25,755	51,658	73	149	+104	—	23	+23
Total	40·2	38·3	− 5	562,779	670,071						

NOTES.—(1) Three ordinary and five prepayment surveys in 1954.
Four ordinary and four prepayment surveys in 1957.
(2) Percentage of copper was 15·9 in 1954, and 1·1 in 1957.
(3) Open reading of prepayment meters was adopted in 1957.
(4) Reduction in labour cost adjusted for change in number of meters : £3,500 in a full year.

tion of work and collection of material.

(2) Time lost in the depôt due to administrative delays.

(3) Time lost between jobs where public transport had to be used, or no transport was available.

(4) Time lost revisiting depôt to:
- (*a*) return material or disconnected equipment,
- (*b*) draw additional or correct material where original pre-delivery was in error.

(5) Abuse of the lunch break.

(6) Time lost telephoning depôt in afternoon to report work completed and, if necessary, accept emergency work.

(7) Tendency of workmen to leave tools at last job of day without knowing where first job of following day would be.

District supervision was exercised by gasfitting representatives, who had two main responsibilities:

(1) To measure new work for the preparation and delivery of materials.

(2) To supervise work carried out in their districts.

It was revealed that the demands made on their time for their first reponsibility had increased so that supervision was reduced to contact with the fitters in the depôt and visits to particular jobs that, because of their nature, required the personal attention of the representative.

Walking Time

Study of the work carried out by semi-skilled maintenance men had shown that, as the duration of the average maintenance job is much shorter than a gasfitting job, walking time between jobs absorbed a much higher proportion of the paid hours. Almost every job involved two visits, the first to diagnose the cause and identify parts required, the second to fit replacement parts. The quality of workmen, who had in the past been recruited from general labourers, was found to be at fault, and the shortcomings of poor selection were accentuated by inadequate training. It should be recorded that the additional reward above labourers' wage rate was small, and not attractive to the best calibre of operative.

Broadly speaking, the old administrative system had been based on two main principles:

(1) All clerical work for sales, gasfitting, and main and service laying was located in a central office, which also handled telephone enquiries from consumers. Estimates for work to be done were, however, sent out by the accounting department.

(2) All personal contact with consumers in connection with selling, measuring, fitting and maintaining equipment was done by gasfitting representatives, gasfitters and maintenance men.

Investigation of office procedure and arrangements showed that these were hopelessly inefficient due to arrears of gasfitting and maintenance jobs and it became evident that complete reorganisation was essential. A new system was therefore devised with the following cardinal principles in mind:

(1) Decentralisation and simplification.

(2) Installation of an overall progress section, responsible for the production of controls and for the progressing of work.

(3) Installation in conjunction with the progress section of a consumers' information centre to handle all telephoned and written progress enquiries.

(4) Establishment of an independent emergency service.

(5) Mechanisation of gasfitting and maintenance operations.

(6) Continuous supervision of gasfitting and maintenance operatives.

(7) Upgrading of quality of maintenance work by re-training of operatives and improvement of status.

(8) Use of radio to simplify and expedite communications and to improve control.

The City of Edinburgh has been divided into six gasfitting and consumer service districts.

Each district is provided with a personnel carrier of the minibus type, driven by a chargehand maintenance man whose prime responsibility is the mechanised supervision of the district maintenance men. Maintenance men also report for duty on the district at normal starting-time at the pre-arranged assembly point for the vehicles. The chargehand issues each man with some three or four jobs and drives him to his first job, arranging a subsequent meeting place with him.

A very great increase in the efficiency of attending to emergency calls has been brought about by the creation of a radio emergency service. Work study and experiment led to the provision of three vans, each with a team of two or three men together with a chargehand driver. These vehicles are in constant radio communication with the central organisation. All emergency calls (escapes, poor pressure or no-gas complaints, defective pre-payment mechanisms, fires, accidents, *etc.*, are communicated immediately to the central radio operator, who in turn transmits to the nearest emergency vehicle. The overall average time from receipt to attendance at such calls has been reduced from 8 hours 45 minutes to 1 hour 15 minutes. The main switchboard has been relieved of 200 calls per day from gasfitters and maintenance men, and 90 manhours of ineffective time telephoning to office each day have been eliminated.

Left to right: Mr. J. L. Anstey, Parkinson Cowan; Mr. H. A. Edkins, West Midlands Gas Board; Mr. W. Q. Foster, Parkinson Cowan; Mr. D. S. Davies, Abertillery; and Mr. L. Mandy, Parkinson Cowan.

The revised system went into full operation on January 14, 1957, and within a month was working smoothly.

The results achieved fall under two headings:

(1) Improvement of standard of consumer service.

(2) Financial savings resulting from improved methods and increased productivity.

The improvements in consumer service can be summarised as follows:

(1) The arrears of gasfitting and maintenance work have been eliminated.

(2) The sub-contracting of installation work has been reduced to a handful of jobs.

(3) The delay in attending emergencies has been reduced from over 8 hours to little more than 1 hour.

(4) The improved quality of workmanship by maintenance men has reduced by 22% the intake of requests for maintenance.

(5) Complaints regarding service have been reduced from 10 to about one per day (the latter frequently without justification), and letters and telephone calls of appreciation are frequently received.

The financial benefits can be summarised as follows:—

(1) The productivity of gasfitting personnel has increased by 52%.

(2) The productivity of maintenance personnel has increased by 75%.

(3) The net reduction in costs of cleri-

the complete job . . .

RESEARCH

DESIGN

MANUFACTURE

ERECTION

WEST'S

GLOVER-WEST CONTINUOUS VERTICAL RETORTS

C.O.L. INTERMITTENT VERTICAL CHAMBERS

WEST'S GAS IMPROVEMENT COMPANY LIMITED
ALBION IRONWORKS · MILES PLATTING · MANCHESTER 10
Tel: COLlyhurst 2961 Grams: Stoker, Manchester
London: Columbia House, Aldwych, W.C.2. Tel: HOLborn 4108
C.O.L. Div: Chandos House, Buckingham Gate, S.W.1. Tel: ABBey 6912

PL4

cal departments has amounted to £4,300 per annum.

(4) The net reduction in costs of gas-fitting and maintenance departments has amounted to £20,600 per annum.

The above costs allow for supervision, interest, depreciation, maintenance and running costs of vehicles and radio communication, and expenditure upon office equipment.

Mainlaying

In contrast with the events that led to the work already described, the initial formal request for the study of mainlaying with a view to the introduction of an incentive bonus scheme came from the operatives themselves in 1957. In this they had been greatly encouraged by the local trade union organiser, whose steady support was instrumental in bringing about the extremely good labour relations that prevailed throughout this investigation.

Method study established:

(1) Absence of uniformity in mainlaying methods, which were largely determined by the individual chargehand mainlayer.

(2) Squad composition not based on a proper balance of work load between each of its members.

(3) Bulk of excavation work carried using hand tools, and, for the most part, pipes and specials moved manually.

It was found that costs could be considerably reduced by a much greater extension in the use of pneumatic excavators and pipe cutters, and the rate of mainlaying substantially increased. Portable winches and cradle trolleys were also provided for each squad. Each member of a squad was allocated to perform specific duties, a squad consisting of one chargehand mainlayer, one mate, and six labourers.

The following table gives a reasonable estimate of the probable increases in output and in the earnings of operatives due to reorganisation of methods and application of an incentive bonus scheme:—

TABLE 2.

Comparison of Anticipated Final Performance of Mainlaying Squads Before and After Introduction of Revised Methods and Incentive Bonus Scheme.

1	Per cent 2
Increase in productivity and output	114
Increase in operatives' earnings	25
Reduction in direct labour cost	41
Annual rate of direct labour savings on 11 squads	£29,000

The discusssion of this paper is held over until next week

Left to right: Mr. A. W. Brown, Portsmouth; Mr. H. E. Dyble, Woodall-Duckham Construction Co., Ltd.; Mr. T. de Roo, N.O.M. Veth Furnace Company.

Personal

MR. R. DAVIS has been appointed by the Gas Council to succeed Mr. W. Bailey as Chief Accountant when Mr. Bailey takes over the Secretaryship of the Council at the end of September. Mr. Davis is at present Chief Accountant of the West Midlands Gas Board, an appointment which he has held since 1949.

SIR HUGH BEAVER, K.B.E., has been re-elected President of the Institution of Chemical Engineers; and Mr. W. K. Hutchison, Chairman of the South Eastern Gas Board, has been elected a Vice-President.

MR. F. ROSSITER has been presented with a garden shelter and three deck chairs to mark his retirement as senior costs clerk after 43 years' service to the Rugby District of the West Midlands Gas Board.

Obituary

MR. WILLIAM R. OLIVER, a former Public Relations Officer for the East Midlands Gas Board, has died aged 61. Born in Huddersfield, he was for some years Executive Officer of the British Commercial Gas Association in London. During part of the war he was seconded to the Ministry of Food, later joining the B.B.C. as a war correspondent. Between the end of the war and nationalisation, Mr. Oliver was P.R.O. to the Sheffield and District Gas Company, then receiving this appointment with the East Midlands Board.

MR. WILLIAM A. KING, who joined the Canterbury Gas and Water Company in 1903 as Chief Clerk and Accountant, became Secretary in 1914, and a Director in 1939, has died, aged 88.

MR. THOMAS MCCARTNEY, Gas Manager at the Galston works of the Scottish Gas Board, has died.

Diary

May 22-23.—SCOTTISH GAS BOARD: Largs, Ayrshire. Area Staff Conference.

May 27.—LONDON AND SOUTHERN SECTION, I.G.E.: Connaught Rooms, Great Queen Street, London, W.C.2. Spring Meeting. Annual Luncheon and Chairman's Address.

May 28.—YORKSHIRE JUNIORS: Hull. Joint Meeting with MANCHESTER JUNIORS. Tour of Gasworks and Docks.

May 28.—WALES AND MONMOUTHSHIRE JUNIORS (NORTH WALES SECTION). Paper by D. J. Turner, Senior Chemist, North Wales.

May 29.—NORTH THAMES G.C.C.: Westminster City Hall, London, W.C.2. Council Meeting.

GLOVER AND MAIN LIMITED

Annual General Meeting—June 5, 1958

CHAIRMAN'S STATEMENT TO SHAREHOLDERS

THE year under review has not been an easy one. We have had many problems to surmount, both in improving our own organisation and in meeting competition. In the circumstances, and with Government restrictions still pressing heavily on our industry, your Company has done well to have increased its margin above that of a year ago. Staff and employees have co-operated successfully in achieving this result. I should like to pay particular tribute to the more senior members of the staff who have borne a heavy burden; they have overcome their difficulties without thought of long hours or personal inconvenience in the most loyal and praiseworthy manner.

New Board Member

At the New Year Mr. Tudor intimated his wish to retire. He joined the Board during the last war and has regularly attended meetings of those of the trading companies with which he was associated, both in this country and in Holland. We shall miss his ever willing advice and have accepted his notice of retiral with great regret. To fill Mr. Tudor's place we have invited Mr. E. D. E. Andrewes to join the Board of this Company and you are being asked to endorse his appointment. He has been a Director of one of our subsidiaries for some years; his principal interests are in other industrial engineering concerns, and we feel that his knowledge and experience will be of great assistance to us in the future.

Profits Doubled

You will see from the accounts which have been circulated with this statement that your Company's combined trading profits for the year 1957 increased from £335,358 to £519,556, and, after meeting all charges, were £358,086—approximately double those for 1956. In recommending to you that the same rate of dividend should be paid for 1957 as previously, your Board has taken into account the very difficult conditions and uncertainties which face the Company at the present time. So long as arbitrary restrictions continue to be imposed upon our market we must view the immediate prospect with reserve, and be prepared for conditions in the industry to become more highly competitive and profit margins lower. By adopting a conservative policy at the present time, we would hope to be in a better position next year to maintain the rate of dividend.

Turning now to the Trading Companies I refer firstly to Thomas Glover which has again experienced a difficult year in the face of severe competition. The policy of concentrating resources begun in 1956 has been continued, and with the establishment of the new prepayment mechanism for domestic meters, sales have improved slowly but progressively throughout the year. The order book for 1958 continues to reflect this improvement notwithstanding the intensification of the competition for a limited market. The importance of research and development cannot be over-emphasised. Activity in this section of the Company's organisation is being further strengthened by extensions to the research laboratory. Unremitting study of materials and all features of design coupled with improved techniques in production and inspection are both essential for the maintenance of the name of Thomas Glover in the forefront of gas meter manufacturers.

Glover & Main Ltd. Trading Results

1956		1957
£176,197	Trading Profit for Year after all charges ...	£358,086
£217,552	Net Profit before taxation	£395,372
£86,679	Net Profit after taxation ...	£195,536
1s. per 10s. share	Ord. Dividends for the year	1s. per 10s. share

R. & A. Main have held their position in the domestic cooker field, although owing to Government policy the national turnover is not as high as we feel it should be, nor as we would wish it, to enable us to run the two cooker factories at a really economic level. The catering equipment side of our business has expanded slowly but steadily, and at the recent Hotel and Catering Exhibition we were able to display a variety of re-designed and modern catering appliances, which are a real advance on those being marketed two years ago. Our intention is to continue to develop and expand our interest in this field. One section of R. & A. Main's activities in which we are particularly engaged at the present time is that of space heating. Your Company has done little in this field since the war, but in 1956 we produced a low cost convector fire and in 1957 we produced the first really high efficiency convector heater in this country; this has enabled the gas industry to offer an appliance that can, for the first time, be used by the consumer at a running cost comparable with that of the coal fire. This new development in appliance design is an achievement as yet not equalled elsewhere, and you may have seen in the national and local Press that we gave considerable publicity to it during the winter. Other appliances on similar lines will follow.

Further Water Heater

Main Water Heaters have produced a further instantaneous heater to follow up the sink heater made available last year, and considering the market, they have achieved reasonable sales. Purchase tax and particularly hire purchase restrictions are, however, such a burden that the public tend only to buy such appliances when the need is urgent. Water heaters are by no means first in the queue in the family budget; consequently the Croydon works is not working at anything like full capacity.

Morley Products at Padiham are in very much the same position with their gas/electric washing machine, but their wash boiler and also hand-operated washing machine have sold well during the year.

Promising Future

As regards the future, we have already had a few months' trading in 1958, and the results up to date have not been promising. We are continuously considering and planning for the more distant future when we hope that an easing of financial restrictions will make for a greater demand for all your Company's products.

In conclusion may I repeat that while your Board feel that the showing for 1957 is satisfactory under present conditions, we have a hard fight ahead of us. In saying so I would express the hope that what I have said above has satisfied you that we are making our preparations, and have the determination to achieve success.